METALLURGIA

The British Journal of Metals

(INCORPORATING THE METALLURGICAL ENGINEER.)

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Cumberland Iron and Steel Works

Visited by Members of Iron and Steel Institute

Of the large number of works visits arranged by the Iron and Steel Institute in connection with its Annual Meeting, held in Manchester, not the least important was the visit to the Moss Bay Works of the United Steel Companies, Ltd., and the Millom Works of Millom and Askam Hæmatite Iron Co., Ltd., and in this article recent developments at these works are described.

THE persistent search for economies in the iron and steel industry has resulted in a considerable degree of reorganisation. Attention has been directed to producing units, and, in particular, blast-furnaces have been modernised or entirely reconstructed, with a view to increasing their capacity and producing on a more economic basis. It is recognised that the efficient and economical operation of blast furnaces is an essential requirement in meeting the manufacturing conditions that exist to-day. Reducing the costs of production to a minimum is of primary importance, and the fundamentals which contribute to this reduction have as their object increased output per furnace. These include control of the materials charged into the furnace, and their mechanical handling; the conversion, cleaning, and utilisation of the gas produced also has an important influence on economical operation.

Much development of this character has been made in the Cumberland area, and the Workington Works of the United Steel Companies, Ltd., and the Millom Works of Millom and Askam Hæmatite Iron Co., Ltd., recently visited by members of the Iron and Steel Institute, proved excellent examples of the progress made in blast-furnace practice, and by the courtesy of the firms mentioned we are able to give some indication of the progress made at these works.

MOSS BAY AND DERWENT WORKS.

The Workington branch of the United Steel Companies, Limited, is a self-contained combination, operating its own hematite iron-ore mines, limestone quarries, coal mines, coke-oven plants, by-product plants, blast furnaces, acid Bessemer steel plant, and rolling mills. These undertakings are situated on the west coast of Cumberland, within an area extending along the shores of the Solway Firth, from Maryport in the north to Egremont in the south. Workington is the concentration point; it is here that the iron and steel plant is situated. This has the advantage of being conveniently near to the Prince of Wales Dock, to which the works are connected by a private railway.

The chief ores used at the blast furnaces are local hematites; of these a large proportion is produced at the Company's Beckermet and Bigrigg Mines, whence they are conveyed to the works by rail. The rough ores are treated at a crushing and screening plant at the works. Limestone, of good quality, is obtained from the Company's Rowrah Quarries, where it is screened and graded, ready for use in the blast furnaces. The Company operates three colliery undertakings in the district, from which are drawn supplies of coal for its two coke-oven plants—the Rusehow Colliery, Coking and By-Product Co., situated near to Maryport, the Moresby Coal Co., and the Harrington Collieries, situated five miles south of Workington. These two latter undertakings have coke-oven and by-product plants attached to them, which are working at present, but a new installation of coke-oven and by-product plant is in the course of construction.

Tapping a blast-furnace at Derwent Works, Workington.

The new plant, which incorporates all the latest improvements in coking practice, is being built by the Woodall-Duckham Co., and adjoins the blast-furnace plant at Derwent; this will enable the coke to be delivered with the minimum of handling direct to the furnace bunkers.

Blast-Furnaces.

At present two blast-furnace plants are being operated—the plant of the original Moss Bay Hematite Iron and Steel Co., situated at Moss Bay, and that formerly of Chas. Cammell and Co., Ltd., situated at Derwent. The latter plant has been extensively reorganised, the furnace lines and equipment have been modernised, and each furnace has been fitted with mechanical charging apparatus. The Moss Bay blast-furnace plant, which is used only as a standby and for the occasional production of ferro-manganese and spiegel, still retains hand-charging methods. The mechanised plant at Derwent consists of three furnaces: No. 2, which is capable of 3,000 tons per week, and which is charged by means of skip hoist and scale car; Nos. 3 and 4, having capacities of 2,200 and 2,700 tons per week, respectively, both of which are charged by a hoist and bucket, the bucket being filled by belt conveyers, which are in turn fed by a scale car.

Modernised blast-furnace plant at Derwent Works.

Blast is provided by five steam turbine-driven turbo-blowing units, two capable of 30,000 cub. ft. per min. at 15 lb. per sq. in. pressure, and three having capacities of 25,000, 20,000, and 20,000 cub. ft., respectively. The blast-furnace gas is conveyed from the furnace dustcatchers, partly to a Lodge Cottrell electrostatic gas-cleaning plant, where it is semi-cleaned for boiler firing, and partly through a Theissen gas-washer for fine cleaning and subsequent use in the stoves.

Acid Bessemer Steel.

The new acid Bessemer steel plant at Workington replaces one which worked practically continuously from its start in 1872 until 1935, and is the only plant in Great Britain making this class of steel. The inherent qualities of acid Bessemer steel are widely recognised. Chief amongst these are : Resistance to wear, advantage of which is taken in the manufacture of steel rails ; free machining qualities, which makes it an important material for use in high-speed production in automatic machine tools ; weldability, which makes it particularly suitable for the manufacture of welded tube strip ; and case-hardening, for which it is extensively used in high-class engineering products.

The characteristics of acid Bessemer steel are such that the Workington Iron and Steel Co. have embarked upon an extensive reorganisation of their acid Bessemer steel plant, which will enable them to pursue further developments in the manufacture of this class of steel.

The new plant is T-shape in layout, and has two 25-ton converter vessels, which are blown by a quarter-crank steam blower, giving 18,000 cub. ft. per min. at 20 lbs. per sq. in. pressure. A 400-ton hot-metal mixer is included. The vessels are electrically operated. The converter and mixer bay is served by a 100-ton overhead crane, which carries out all the lifting work connected with hot metal and steel ladles. The steel ladle during tapping rests in a rope-driven transfer car, in which it is transferred when full to the casting shop.

The casting shop forms the stalk of the T, and is served by a 100-ton casting crane. After casting, the ingots are passed down the shop, and are stripped by a 5-ton stripping crane before they are shunted into the soaker building. The hot moulds are placed for cooling upon a cooling rack, which occupies the centre of the stripping bay. Ingots are charged into two gas-fired soaking pits, which are adjacent to the rolling mills, and an ingot chariot conveys ingots to the cogging mill. The latter portion of the steelworks reorganisation is not yet completed, but work is at present going on, and it is anticipated that the new soaking pits will be in commission by September, 1935.

Rolling Mills.

The 36-in. cogging mill is driven by a 2,000-h.p. steam engine, and blooms pass on from this mill to be cropped at a steam shear before they are rolled down in a 32-in. roughing mill, and, finally, finished in a three-high 30-in. finishing mill, both of which are driven by steam engines. The finishing mill rolls rails, billets, slabs, sheet bars, and other heavy sections. Running parallel to this mill is a 22-in. mill fed by a continuous-producer gas-fired furnace, in which are rolled fishplates and other light sections. This mill is equipped with its own hot saws, punches, and cooling banks. The main finishing mill runs out on to extensive cooling banks, where the various products are marshalled for inspection and final despatch.

In recent years the Workington Iron and Steel Co. have been operating a Sandberg sorbitising plant, and a considerable quantity of rails has been treated by this process. The plant itself is conveniently situated parallel to the run out rack from the finishing mill, and rails, after treatment, pass into a Sandberg oven, where they are allowed to cool slowly before proceeding to the straightening and ending machine.

Products.

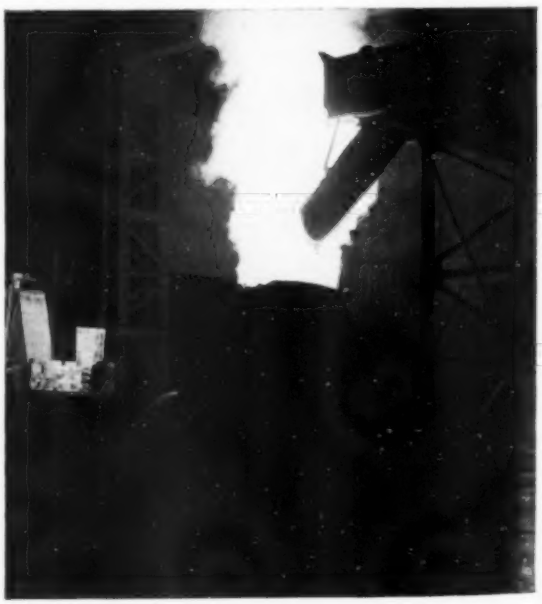
The range of products manufactured by the Workington Iron and Steel Co. comprise foundry and steel works hematite irons, cupola refined irons, and special "All Mine" UCO refined and cylinder irons. At the Moss Bay furnaces the production of ferro-manganese and spiegel is undertaken. A new departure in relation to pig iron is the installation of a pig casting machine.

The chief steel products made from acid Bessemer steel are rails and fishplates, etc., billets and slabs for the manufacture of tube strip and for special purposes ; sheet bars and untested soft steels, to compete in markets which have in the past depended upon imported Thomas steels. The acid Bessemer steel produced has unique inherent qualities in regard to mechanical strength and ductility, weldability, wear resistance, and good machining qualities.

MILLOM WORKS.

The original plant of Millom and Askam Hæmatite Iron Co., Ltd., the erection of which was commenced in 1865, comprised a group of six furnaces with open tops 50 ft. in height, and with hearth diameters of 6 ft. A single hoist in the centre of the group sufficed for charging purposes, and hot blast was obtained from the usual pipe stoves, then in vogue, pressed up to about 3 lb. by a pair of beam blowing engines. At that time the Company was incorporated under the title of The Cumerland Iron Mining and Smelting Co., Ltd., and Millom was selected for the erection of the plant as a result of the discovery in the vicinity of the extensive deposit of hematite ore, and

New acid Bessemer plant at Workington.



to the shipping facilities offered by the Duddon Estuary. Although the ores used in those early days were almost wholly obtained locally, it is interesting to note that small quantities of foreign ore were also imported directly into the works from Spanish and Mediterranean ports. In 1905 the Company in their search for independent ore supplies became owners of the Ullbank Mine, in the Egremont district of West Cumberland, which ultimately led to prospecting in the vicinity, resulting in the discovery of the magnificent deposit of hematite ore now known as the Florence and Ullcoats Mines, which will ensure continuity of supplies of West Coast hematite ore for some time to come. The hematite iron ore produced at these mines is of the highest grade and eminently suitable for the production of Millom high-grade special iron. The mines are equipped with most modern types of crushing and screening plants, and are thus enabled to supply fine ores suitable for the manufacture of paints, annealing ores for the malleable trade, crushed and screened to any size to meet customers' requirements, crushed blast-furnace ores, and hand-picked lumpy ore for steel works. Apart from the West Coast hematite ores the Company own the Alquife Mines and Railway Co., Ltd., operating hematite iron ore mines in the south of Spain, the Alquife ore being a very pure mineral easily and cheaply smelted, which makes a splendid mixture with the West Coast ores of the Company. This ore is supplied to the market as screened ore or fine ore for sintering purposes.

In common with most other concerns engaged in the production of iron and steel during the past few years, it has been found essential to explore every possible source from which economy in production might be expected to accrue. With this object in view therefore, in 1932 the Company decided to embark on a programme of reconstruction of the Millom plant, based on combining the latent resources of their mining properties with the most enlightened blast-furnace practice. This, it is confidently anticipated, will mark a definite forward step in the economical production of all brands of hematite pig iron.

The programme, when completed, will provide the following equipment: Three modern blast-furnace units of 250 to 270 tons per day capacity; stove reconstruction embodying fillings to operate with cleaned gas; Theissen washers of 2,000,000 cub. ft. capacity; new service bunker accommodation; additional electric generating capacity; provision of a sinter plant of 500/600 tons per day; and grading and sizing of all materials.

At the moment most of the above-mentioned items are installed. The first of the new furnace units is in operation with its complement of stoves and bunkers, whilst the second furnace and hoist has just been completed. Four additional Stirling boilers have been installed, and the gas-cleaning plant has been in service for the past 18 months. The erection of the sinter plant, with its attendant accommodation for raw materials, is proceeding at present, and is well forward. It is expected to be in operation during the next few months.

It is not intended to provide a new furnace to make up the third unit. The present No. 1 furnace is of comparatively modern construction, and it will be partially dismantled and bodily lifted to conform with the raised hearth levels of the two new units.

Furnaces.—The furnace units are 78 ft. high, 14 ft. hearth, 20 ft. bosh, and 14 ft. 9 in. throat, and are provided with double bell tops for hand charging. Hearth levels are 10 ft. above ground, and all steel-plate construction of hearth jacket and tuyere belt has been adopted. The hearth is cooled by internal cast-iron water-cooled blocks, extending from 8 ft. below hearth level to 3 ft. above. Ten 5½-in. tuyeres are provided, each housed in two concentric copper cooler blocks, whilst three rows of flat copper coolers are arranged around the tuyere belt, two rows above the tuyere centres, and one below, 30 blocks in all. No stock cooling is provided. The bosh jacket is comprised of ¾ plate, and is spray cooled, as is also the outside of the hearth jacket. The columns, 10 in number, and lintel are composed of rolled steel sections, and a working platform, 10 ft. 6 in. wide, is provided around the hearth.

No. 3 Blast-Furnace at Millom.

The top auxiliary bell is 6 ft. diameter, and the main bell 10 ft. diameter, both operated by compressed air and oil brake. Charging is accomplished by vertical hoists, electrically operated. Reinforced concrete bunkers accommodate ore, coke and limestone conveniently situated close to the hoist.

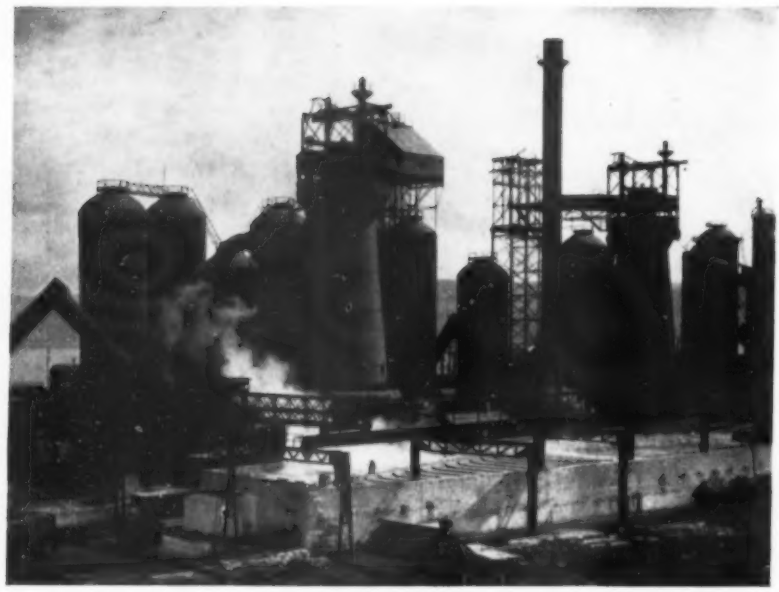
Stoves.—The stove units, as regards shells, were in excellent condition prior to the present reconstruction, having been renewed during the war period and after. It was only necessary, therefore, to provide more efficient fillings. Four stoves have been allocated to each furnace, 90 ft. to 100 ft. high, and 21 ft. diameter, of the Cowper pattern. The old fillings of 7-in. and 8-in. diameter chequer-work have been removed for 50 ft. down and replaced by Hartmann spiral bricks, providing a heating surface of 85,000 sq. ft. in the case of the 90-ft. units, and 90,000 sq. ft. in the 100-ft. stoves.

Each furnace unit, with its complement of stoves, is entirely isolated from the rest of the plant as regards hot and cold blast connections. New hot blast mains for each unit have been provided, lined with an outer course of 4½-in. insulating bricks, as is also the circular main around the furnace. Large cold blast mixing valves are fitted in the end of the hot blast mains, operated by thermo couple and motor unit, for the maintenance of a uniform hot blast emperature.

Each furnace unit is provided with a separate record room for housing its complement of instruments, which include hot blast pyrometer and recorder, top temperature recorder, blast volume recorder, stove gas-pressure recorder, blast pressure recorder, and mixer valve controller. A Freyn design stock level recorder is also in hand.

Blowing Plant.—The blowing plant consists of three high-pressure turbo-blowers, each of 30,000 cub. ft. capacity, at 8 lb. to 12 lb. pressure, with revolutions of 2,800 to 3,300, respectively, and operating with a steam pressure of 150 lb. per sq. in., superheated 150° F. Each furnace is coupled direct to a separate blower unit, with arrangements for changing over to the spare unit when necessary.

Electric Generating Plant.—For the provision of electric current three turbo-alternators are installed of 500 kw.



General view of blast-furnace plant at Millom Works, showing Nos. 2 and 3 blast-furnaces.

capacity each, generating at 500 volts 3-phase 50 periods. A certain quantity of this current is stepped up to 6,600 volts for transmission to the limestone quarries one mile distant, whilst current at the same voltage is also supplied to the Urban District of Millom for lighting purposes through a central transformer station in their area.

Gas-cleaning Plant.—The cleaning of gas has been adopted mainly for the purpose of stove firing. Any available gas, after stove requirements have been met, is passed into the boiler gas main, boilers therefore are fired to a large extent with crude gas.

Sintering Plant.

The sintering plant which is now in course of erection will be an item of considerable interest to the members of the Iron and Steel Institute, though it will not be ready for operation at the time of the visit. It will convert the ore fines from the company's hematite iron ore mines into sinter, as it has been found that the Company's Alquife fine ore, when mixed with the Florence fine ore, makes an ideal combination for the production of a high-grade sinter. The sintering plant is of the A.I.B. type, and is designed for a daily output of 500/600 tons. It consists of eight sinter pans 9 ft. 9 in. diameter. An extension in width over the whole length of the existing service bunkers for ore and coke provides stocking accommodation for 11,000 tons of fines with the necessary fuel and bedding material, while centrally situated in this line of stock beds is a crushing plant for handling the coke breeze to be used as fuel and for providing the bedding ore. The ores will be brought from the ore storage bin by a grab crane and discharged into three feeding hoppers which are of such design as to prevent "hanging up" of the material and to ensure free exit. Material will be taken from these hoppers by belt conveyors to a steel-band conveyor which feeds the raw material service hoppers. The material from these latter hoppers is discharged over a rotary feed table on to a belt conveyor and thence on to a steel band mixing conveyor where the necessary amount of moisture is added by special sprays. The material is then subjected to a thorough mixing by means of a series of ploughs, and delivered by a skip hoist into the charging bunkers for the sinter pans. Empty sinter pans are placed under the charging bunkers by means of an electrically-propelled car for loading the fully-charged pans, and are then raised and carried on an overhead travelling crane and placed in the pan stands in the main hall of the building. The fully charged pans of raw material are ignited by means of a rotary type travelling ignition apparatus working with clean blast-furnace gas under pressure. The air required for combustion is drawn through the charges by means of electrically-driven fans, the fumes being delivered through a main flue to the chimney. The sintering plant building is of reinforced concrete structure, and the feed bunkers provide accommodation for 24 hours' supply of sintering material. Space is reserved for four additional pans to be provided if necessary. The pans are arranged in rows of four on each side of the building with sufficient space in the centre to allow of the ignition car travelling between the rows. For operating purposes the pans are divided into groups of four, each pair of pans being coupled to one induction fan.

Site of Plant.

Although the elevation of the site of the plant leaves something to be desired in respect of its relation with ordnance datum, it was probably the best which the original founders could accomplish, having regard to one of the fundamental features which governed their choice—viz., to provide ready access to a shipping wharf. The Company's private wharf is therefore situated within a few hundred yards of the works, and in direct communication therewith. As the Duddon Estuary is tidal, and subject to the steep range between springs and neaps on this part of the coast, it is only possible for shipping to be carried on to any extent during spring tides. Nevertheless, this facility of coast-wise shipping enables the Company to successfully enter the South Wales, Glasgow and Continental markets. During spring cargoes of over 1,000 tons can be shipped, and, as the shipping wharf is some eight miles up the Estuary from the open sea, the Company is also responsible for the buoying and maintenance of a suitable channel.

The plant has been designed, and is being erected to drawings supplied by the Coppee Co., of Great Britain, Ltd., 44, Grosvenor Place, London; the Millom Co. undertaking the whole of the erection of the plant both in steel and reinforced concrete.

Up to 1885 it was not usual to specify pig iron by analysis, but about that date various degrees of silicon were specified by certain customers. Later, however, it has become the rule to order all pig iron by analysis, which enabled the Millom Company to establish a reputation for the production of special hematite pig iron.

APPROXIMATE RANGE OF ANALYSES OF "MILLOM" HEMATITE PIG IRON.
SPECIAL "MILLOM" HEMATITE.

	Silicon.	Sulphur.	Phosphorus	Manganese
	%	%	%	%
0·02% quality	1½/2½	0·015	0·019	0·16 to 1
0·025 ,, ...	1½/2½	0·022	0·020	0·16 to 1
0·03% ,, ...	1½/2½	0·026	0·023	0·16 to 1
"MILLOM" HEMATITE.				
Mixed Numbers.....	1½/2½	0.03/0.04	0·025	0·16 to 1
1, 2, and 3.....	2nd Bessemer 2/2½			
Ordinary 3 Foundry ..	1/2	0·055	0·03	0·16 to 1
Ordinary 4 Foundry and Forge	0·07	0·075	0·03	0·16 to 1

Note.—Silicon and manganese contents can be varied and selected within reasonable limits to suit customer's requirements.
The total carbon content is approximately 4%.

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METAL MELTING

Its Effect on Quality

THE meetings of the Institute of Metals at Newcastle-on-Tyne, and the Iron and Steel Institute at Manchester, held this month, have been in many respects eminently successful. The attendances in each instance were good, the various visits and excursions were interesting and enjoyable, and the level of the scientific contributions high. In particular the number of valuable discussions was noteworthy. No spectacular discoveries were presented, but ample evidence was given that knowledge of metals and alloys is increasing, and its fuller application in industry is having and will continue to have immense possibilities. It is interesting to note that metal melting was given special consideration, not only in the lecture before the Institute of Metals, by Dr. H. W. Brownsdon, but in several papers presented at each meeting.

The modern trend in manufacture is towards improved quality. This trend towards higher quality primarily concerns ferrous and non-ferrous metal manufactures, and is due to the need for metals and alloys possessing superior mechanical properties, greater reliability, and capable of giving increased service. The severe duties imposed by modern aeronautical and automobile engineering developments, the advent of high-pressure steam boilers and high-pressure high-temperature chemical plant, together with developments in practically every branch of engineering, have increased the demands of engineers for materials of high quality. Specifications have become more and more exacting during recent years; metals and alloys are expected to satisfy very severe tests, often after forging and suitable heat-treatment, and as these operations are costly, it is becoming increasingly necessary that their quality is of a high order.

The fact that particular attention was directed to metal melting at these meetings is an indication that its influence on quality continues to be appreciated. It was this aspect of the subject which constituted the basis of Dr. Brownsdon's lecture, who defined quality for his purpose, not in terms of specifications, but on much broader lines—namely, that a metal of high quality is that which meets the needs of the user to the fullest extent. He made it clear that in one and the same metal or alloy very small changes in composition may render it suitable for one application and unsuitable for some other. From a metal-melting point of view, this control is in effect a control of composition, and it is in accurate control of composition that difficulties associated with metal melting arise. It was shown that melting for quality presents many difficulties even when virgin metals are the only raw materials used, but the use of scrap, an economic necessity, still further complicates the problems involved, which are similar but more intense than those associated with virgin metals. In addition to any undesirable constituents which may have been present in the original virgin metals, scrap may have suffered deterioration during the melting operations through which it has passed and, further, it may be contaminated by adherent as well as constitutional impurities. Methods adopted for removing undesirable impurities were discussed, and the difficulty of obtaining the desired object was stressed. Perhaps one of the most difficult of the operations in dealing with molten metals is to free them from gases, and special reference was made to this aspect of metal melting as well as other special factors bearing on the quality of the product.

Stress was laid on the little things that matter in metal melting, and that, in spite of all the scientific investigation work that has been done on molten metals, some of their secrets still remain unrevealed. It is important, however, to bring such scientific developments as have been achieved into practical application without delay and in such a way that success will result. In recent years, for instance, much has been heard of various means of de-gassing aluminium and its alloys, and some of these methods have proved successful, not only in the laboratory, but on a manufacturing scale. They, however, constitute a complication in the production process which would be gladly avoided. The only rational manner of achieving this end is never to allow the metal to be contaminated with gases, especially hydrogen, which seems to be the chief offender. Much can be done in this respect by control of temperature, since it has been shown by many works that the solubility of hydrogen in aluminium and its alloys is extremely small in the region of the melting point, but increases with rise of temperature.

Apart from defects occurring in metals and alloys from their chemical composition arising from the raw materials used, the method of melting, the temperature and method of casting have a considerable influence on the quality of the resultant product. Considering the magnitude of the many factors which influence the quality of metals and alloys, it is remarkable that such excellent results are achieved, but the ability to reproduce a given result is only possible, in perfection, when the full details of manufacture are quantitatively recorded with accuracy. This is one of the objects of a Joint Committee of the Iron and Steel Institute and the British Iron and Steel Federation, which has published in its sixth Report, the results of further investigations designed to increase existing knowledge on the production of steel ingots.

The difficulties referred to by Dr. Brownsdon concerned non-ferrous metals, but they apply with at least equal force to ferrous metals, because in the investigations relating to steel ingots it has been a matter of great difficulty even to enumerate and to schedule all those factors which may or may not have an influence on the result. Even when the desired data has been determined, it is not always practicable or possible to obtain the necessary quantitative record.

It would seem that the complexities associated with the production of ferrous and non-ferrous metals increase the more the subject is investigated, but fundamental work of this character is bound to lead to a fuller knowledge not only of the nature of metals as a whole, but directly upon methods of handling and treating them when molten. Work of this character will not only assist in revealing the secrets which still remain unknown, but will facilitate manufacture, so that the ideal condition of quality may be more nearly approached with, what the user dares to hope, a greater degree of regularity.

RESEARCHES RELATING TO TIN

Equilibrium Diagrams of Binary Alloys of Tin

This book contains 67 diagrams relating to the binary alloys of tin with no fewer than 34 of the elements. To the research worker they are useful because they indicate which groups of alloys are likely to be capable of improvement and development. The practical man who is concerned with the preparation of alloys containing tin for specific purposes will find the diagrams a valuable guide to the attainment of the properties he desires his alloys to have.

The constitution of binary alloys and the interpretation of equilibrium diagrams have been clearly and concisely explained in the introduction to this work, and increase the value of the book for those who have not previously studied the subject academically.

The data have been taken from the original literature. The diagrams are arranged alphabetically, according to the name of the element alloyed with tin. Beneath each diagram is a table containing data regarding the temperatures of the various transformations and the ranges of composition, expressed in percentages by weight of the alloys in which they occur. The book should prove of value as a work of reference to the practical man, as well as to the research investigator. By Ernest S. Hedges, D.Sc., M.Sc., Ph.D., A.I.C., and C.E. Homer, B.Sc., Ph.D.

Black Spots on Tin and Tinned Ware

Black spots are sometimes a difficulty in the dairy industry, and they may form on tin or tinned surfaces exposed to dairy products which are practically neutral. Researches by Dr. Sven Brennert of Aktiebolaget Separator, Stockholm, show that these black spots consist mainly of stannous oxide produced by corrosion which takes place in accordance with electro-chemical principles. Dr. Brennert has elucidated these principles very carefully from the electro-chemical standpoint, and this publication includes a full description of the methods and apparatus employed.

When the potential of the tin surface exceeds a certain amount, depending on the composition of the solution, black spots may begin to form. Once formed, they may continue to grow at a lower potential than this. The effect of different factors on the potential has been studied in a great number of tests. The black spots are prevented from forming by reducing the potential on the tin, and methods of doing this are discussed. A practical way that has given good results in milk vessels is to place a piece of a metal less noble than tin, for example, aluminium or zinc, in contact with the tin surface.

Improved Cleaning Solutions for Tinned Ware

The removal of tin by chemical attack ffom the tin linings of the steel and copper vessels used in the dairy industry occurs almost entirely during the cleaning operations. Hot solutions of sodium carbonate are largely used to remove the milk films from dairy plant, but they attack and remove the tin. Researches carried out by R. Kerr, M.Sc., Ph.D., have shown that small amounts of sodium sulphite added to alkaline solutions cause a great reduction —actually to about one-tenth part—in the attack on tin coatings. Results of several series of experiments are given, with graphs, and it is deduced that the beneficial effect of the sulphite is due to its power to react with the oxygen dissolved in the detergent solution.

The experiments which are described in this publication were carried out with concentration of sodium carbonate or caustic soda similar to those normally used in cleaning operations and over a range of temperature from 40° C. to 100° C. It is remarked that as well as being the most efficacious agent for absorbing oxygen amongst those tried, sodium sulphite is inexpensive, relatively stable in the solid state, readily soluble in water and alkaline solutions : further, its oxidation product, sodium sulphate, has no deleterious effects.

The Twinning of Single Crystals of Tin.

At the Physical Society a few weeks ago Bruce Chalmers, B.Sc., Ph.D., read a paper on the above subject. A new optical method of measuring the orientation of the crystals was developed for the investigations. The experiemental work, which is fully described in this publication, consisted in the preparation of the crystals as cylindrical bodies about six centimetres long, and half a centimetre in diameter, the measurement of the orientation, qualitative investigations of the conditions under which twinning occurs, and a quantitiative examination of the energy involved in the process. For the optical examination, the specimen cylinder, after etching, is mounted on the rotating axis of a gondometer and a converging beam of light, passing through a hole in a screen in front of the cylinder, is reflected back on to the screen. The light thus reflected does not follow the directions taken in the case of cylindrical surfaces, but is inclined at angles to the geometrical normals of the cylinder. Well-defined spots, as many as 20 in a complete rotation of the specimen, are observed on the screen due to planes corresponding with the elementary crystal facets of which the apparently cylindrical surface s composed.

The methods of producing twinning and of reverting to the original orientation, both of which phenomena are accompanied by an audible click, are described. Quantitative results obtained by a ballistic pendulum method showed consistent energy losses when twinning occurred ; this loss appears to be in approximately linear proportion to the volume twinned, amounting to 8×10^5 ergs per c.c. Confirmation of this amount was obtained by measuring the temperature rise which accompanied the change. The results are discussed from the point of view of the crystal lattice structure.

Copies of any or all of these publications relating to tin may be obtained free of charge from the International Tin Research and Development Council, Manfield House, 378, Strand, London, W.C. 2.

A New Piston Alloy

Extensive research and experiment has resulted in the recent development of a new alloy suitable for the manufacture of pistons for aircraft and motor-car engines. This alloy, which is known as "Pistonel," has a very low specific gravity, and a coefficient of linear expansion almost equal to that of cast iron. It is very close in the grain, and is easily sand or die cast, machined, spun, rolled into sheets, rods and sections, drawn into tubes and wires, extruded, and forged and welded. It is claimed to have double the strength of aluminium, and its strength is maintained at elevated temperatures, while, in many respects, it is stated to be superior to most of the alloys at present being used in the making of pistons for internal combustion engines of the types mentioned.

In addition to its use for pistons, its high-tensile strength combined with low weight, together with its capacity for taking a high, lustrous and lasting polish, makes it suitable for many other parts of aircraft and motor-car construction where low weight is an essential factor. A further important characteristic is its high resistance to corrosion, especially in sea-water.

The following figures are given as the range of physical properties of this alloy depending upon the treatment to which it is subjected :—

Tensile strength, in tons per square inch	12 to 35
Elongation %, in 2 inches	1·5 to 35
Reduction of area, %	20 to 66
Brinell hardness	60 to 165
Coefficient of expansion, per 1° C.	0·000012
Modulus of elasticity	8·750·000 to 23·000·000
Specific gravity	2·70

IRON AND STEEL INSTITUTE

Annual Autumn Meeting at Manchester

This meeting was in many respects eminently successful: the attendance was remarkably good, the visits, excursions and functions were interesting and enjoyable, and the level of scientific contributions high. In this article brief summaries of various papers are given.

THE Annual Autumn Meetings of the Iron and Steel Institute were held at the Manchester College of Technology, September 17 and 18. A comprehensive programme had been arranged for members and their ladies which made the meeting a memorable one to those who participated. Many took advantage of the invitation to visit the College of Technology, which was open for inspection during the evening preceding the opening day of the General Meeting. A civic welcome was accorded the Institute by the Rt. Hon. the Lord Mayor of Manchester (Alderman Samuel Woollam, J.P.) on the morning of September 17, in the Great Hall of the College. A cordial welcome was also extended by the Rt. Hon. the Earl of Crawford and Balcarres, P.C., K.T. (President), Mr. J. E. James (Chairman), and members of the Reception Committee. Subsequently, a Business Meeting of members was held, and the remaining time was devoted to the reading and discussion of technical papers. The General Meeting held the following morning was devoted entirely to the reading and discussion of technical papers.

An interesting feature of this meeting was the large number of works visits arranged. In addition to many official visits several companies offered facilities to members for alternative visits to works during the afternoons of September 17 and 18, and generally these optional visits were much appreciated. Not the least interesting of the works visits was that to the works of the United Steel Companies Ltd., and Millom and Askam Hæmatite Iron Co., Ltd., on the Cumberland coast; this, coupled with the drive in the Lake District for ladies and members not visiting the works, was admirably arranged and proved a great success.

Of the technical papers presented at this meeting the most important was undoubtedly the Sixth Report on the Heterogeneity of Steel Ingots, but many valuable papers were included, and it is regrettable that, owing to the limited time, very few could be read and discussed. Some 13 papers were presented, brief abstracts of which are given in the following notes.

Sixth Report of the Heterogeneity of Steel Ingots.*

This report, by a joint committee of the Iron and Steel Institute and the British Iron and Steel Federation to the Iron and Steel Industrial Research Council, gives the results of further investigations and of the further consideration of interesting features of the heterogeneity of steel ingots. The committee has been at work since 1924, and the nature and content of their reports, including the present report, reveal the vast amount of further experimental work which is really necessary for a satisfactorily progressive development of the subject. At the outset the committee realised that it was essential:—(1) to have exact pictures of the heterogeneity of ingots cast from different steels, made by various processes, under different conditions and forms of technique; (2) to know how the experimentally observed result had been produced with such accuracy that repetition could be satisfactorily achieved industrially; (3) to know *why* the particular procedure produced the observed result.

In the investigations previously reported 62 ingots have been studied, and the present report, which is composed of 12 sections, gives an account of the committee's further study of commercial ingots. Three ingots of rimming steel have been made and examined; two from steel made by the basic Bessemer process, and one from steel of high purity made by the basic open-hearth process. Two further examples of killed steel ingots have been made: one, an ingot of 18/8 chromium nickel Staybrite type acid-resisting steel, and the second example, several ingots of austenitic 13% manganese steel. A further example of steel incompletely killed has been studied in an ingot of special steel low in carbon, silicon and manganese. Two experiments on the centrifugal casting of steel are described.

Sections III. and IV. give the results to date of the researches upon the oxygen content of steel carried out respectively under the direction of Professor Andrew, at Sheffield University, and Dr. Desch, F.R.S., at the National Physical Laboratory. These investigations are presented separately and advantages will be gained from the fact that they are conducted independently from each other. A bibliography of knowledge extant as regards the oxygen content of steels is given in section V.

It was realised some time ago that insufficient quantitative knowledge existed as regards the amount of nitrogen present in steel ingots of various types, and also with regard to the distribution of such nitrogen as is present. A more exact visualisation of the nitrogen content is rendered possible as a result of the work of Dr. Swinden and Mr. Stevenson, which is published in section VI. The authors have studied the actual distribution throughout the ingot, and the exact method employed in the determination of nitrogen is fully stated for the advantage of other investigators in this field, who may be seeking to compare the results obtained with other determinations. It is noteworthy that this work is being extended, and it is likely that other data will be available in the future. Along with the work of Dr. Swinden and Mr. Stevenson a fairly complete bibliography on the occurrence of nitrogen in steel has been prepared by Mr. G. C. Lloyd, which is given in section VII.

Some experiments on gases in iron and steel, and their effects on the solidification of ingots are described by Dr. Swinden and Mr. Stevenson in section VIII. It will be recalled that in the Fifth Report Edwards and Jones presented a study of the influence of varying oxygen and carbon contents in iron upon the position of blow-holes in steel ingots. Contemporary with this, work of a similar

* Published as: Iron & Steel Institute Special Report No. 9, by the Iron & Steel Institute, 28, Victoria Street, London, S.W. Price 16/-

character was in progress, the first results of which are described in this section of the report. These two researches provide new and important data concerning the manufacture of rimming steel.

A new aspect of the influence of the gas content on the properties of steel is presented by Professor Andrew and Mr. Ellis in section IX. From experiments it was found that the result of melting steel in a vacuum is to remove a relatively large percentage of the carbon and the greater part of the manganese, along with almost the whole of the oxygen.

Segregation is considered in section X, as a result of an investigation by Professor Andrew and Mr. Trent. Small chill castings, weighing about half a hundredweight, made by the crucible process, after blowing (1) air, (2) hydrogen, and (3) nitrogen through the molten metal just prior to casting, were sectioned and examined, and compared with ingots of similar weight killed with aluminium. The authors put forward a theory in which the suggestion is made that when gas, either hydrogen or carbon-monoxide, attains a certain concentration in that portion of the liquid which is the last to solidify, it will, under certain conditions, depending on the rate of freezing, force out the impure liquid, thereby concentrating the impurities in the surrounding parts of the metal. The position of segregates relative to rimming and killed steel, respectively, is dealt with. Further work upon the position of blowholes in steel ingots is contained in section XI. In a previous paper published in the committee's Fourth Report, Dr. Edwards and Mr. Jones described the effects of varying contents of oxygen and carbon in steel. In the present investigations, principal Edwards and his assistants Messrs. Higgins, Alexander and Davies, decided, first of all, to study the types of ingots produced by variation of the casting temperature with steel of different oxygen and carbon contents, and also to show the effect of mould design and mould temperature on ingots of similar type. The first part of the investigation has yielded positive results of value and interest, but, although in one or two cases slight differences were observed, corresponding to a variation in the thickness of the mould, the size of ingots under consideration was probably too small to show any appreciable effect.

In the last section, which is in two parts, Dr. Northcott attempts to ascertain the form in which the elements carbon, silicon, manganese, phosphorus, sulphur, and oxygen are present in both liquid and solid steel, and in the second part discusses the influence of differential solidification on the segregation effects in steel ingots. Dr. Northcott has provided a useful summary of the state of the theoretical position up to date, which provides a most useful basis for further argument. In the committee's opinion, however, it is clear that further work is required before a complete knowledge of what happens during the solidification of a steel ingot becomes available.

Some Aspects of the Fatigue Properties of Patented Steel Wires.

II.—Note on the Effect of Low-Temperature Heat Treatment.

The effect of low-temperature tempering treatment on the fatigue properties of steels for use in the form of springs has been examined by Messrs. E. T. Gill and R. Goodacre. In this investigation four steels of 0.37%, 0.55%, 0.79% and 0.86% carbon content, respectively, were drawn to varying reductions, from 25% to 90%, and tempered in the range 150° C. to 400° C. The wires were free from decarburisation, but not polished. As a result of this investigation, described in this paper, the authors conclude that generally there is an increase in the limiting fatigue strength, the optimum temperature being of the order of 200° C. (for one steel, 0.79% carbon, it was 150° C.). With all the steels examined there is a critical reduction, at which point under certain tempering conditions the limiting fatigue stress may fall considerably below that for the as-drawn condition. This critical reduction becomes progressively lower as the carbon content increases.

The so-called cleanliness of the steel seems to have a bearing upon the results. The steel with the least amount of manganese, sulphur, and phosphorus present gave the most widely varying figures, while for the steel containing the most of these elements the fatigue limit never fell below that for the as-drawn condition. The results generally support the precipitation theory of hardening.

Fatigue limits as high as ± 44.9 tons per sq. in. were obtained, and the authors suggest that if the materials are polished, a fatigue limit of the order of ± 55 tons per sq. in. should be possible. As far as has been ascertained, there is no direct relationship between the usual physical tests (bends, torsions, etc.), and the limiting fatigue stress.

The Use of the Hele-Shaw Apparatus in the Investigation of the Flow of Metals.

In this paper by Mr. A. M. Herbert and Professor F. C. Thompson an investigation is described in which an attempt has been made to apply the Hele-Shaw apparatus to the examination of some simple forms of drop stamping, to the drawing of tubes and mainly to an investigation of the nature of the flow during the drawing of wire. No differentiation has been made between hot and cold working, since streamline flow occurs in both instances, different though these processes are in their effects upon the properties of the deformed metals.

The authors have studied the correspondence which may be obtained between the flow-lines obtained with the apparatus and those actually found in the metals themselves. Typical drop-forgings, tubes and wire which have been investigated show the degree of agreement to be good. The authors conclude, therefore, that it is legitimate to employ this type of apparatus where the mode of flow during any process of deformation is required to be known. In the design of dies for the production of drop-forgings, for instance, it is probable that invaluable evidence could be obtained of a kind which is not otherwise readily available.

Waste-Heat Boilers in Open-Hearth Practice.

Statements made at the Fifth Open-Hearth Conference, held on October 21, 1932, revealed divergence of opinion as to the value of waste-heat boilers, and the Open-Hearth Committee decided to initiate investigations into the economic value of this type of boiler regarded as a steam-generating and fuel-saving adjunct to the open-hearth furnace. The research on the subject was carried out by the Technical Department of the British Iron and Steel Federation acting for the main committee.

The results of this investigation are recorded in this report, which presents data from a carefully prepared and accurately recorded trial on a waste-heat boiler at the works of the Park Gate Iron and Steel Company. The greater part of the preparation for the trial devolved upon the technical officers and staff of the Park Gate Company, as well as the bulk of the actual recording of data during the week's duration of the trial. Assistance was furnished by Messrs. Steel, Peech and Tozer, who lent three observers from their Templeborough Works, while supervision of the trial was shared between the Park Gate Company and the Technical Department of the Federation. In addition to the results of the trial, a full description of the methods of measurement employed is given in this report.

The economic factors governing the profitable installation of waste-heat boilers are also considered. A method of calculating the net saving due to the steam producton is set out, which is recommended by the committee for this purpose ; the benefits due to improved furnace operation as a result of greater draught being available are recognised as being important, but are calculable only for individual instances; in some cases existing chimney height is adequate, whereas in others a new furnace chimney of

suitable proportions would provide the improved draught at less expense than a waste-heat boiler.

Engineering aspects of waste-heat boiler practice, are given in a contribution by Mr. A. F. Webber, in which notes on installation and operation are incorporated as well as a method of waste-heat boiler design, which will enable those considering a waste-heat boiler installation to estimate probable dimensions and outputs with reasonable accuracy. The report includes a brief historical review of progress in waste-heat boiler practice, together with a bibliography of publications on the subject.

Investigation of the Behaviour of Metals under Deformation at High Temperatures.

PART I.—STRUCTURAL CHANGES IN MILD STEEL AND COMMERCIAL IRONS DURING CREEP.

The object of the work described in this paper by Dr. C. H. M. Jenkins and Mr. G. A. Mellor is to correlate the structure and constitution of alloys with their behaviour at high temperatures. It has been undertaken in the Metallurgical Department of the National Physical Laboratory as a portion of the programme of the Committee on the Behaviour of Materials at High Temperatures.

The present work contains the results of a study of the effects of deformation at high temperatures of several varieties of iron and mild steel, and shows marked differences in behaviour which are probably related to the mode of manufacture. The study has been made by microscopical examination of material subjected to creep and short-time tensile tests at high temperatures, the test-pieces being kept free from attack by air by stressing *in vacuo* in special testing units.

The nature of the creep movement has been studied in relation to the structural changes observed both on the surface of a polished test-piece and on internal sections. The investigation shows that slip, grain boundary movement, and recrystallisation are prominent features in the mode of deformation at high temperatures. Spheroidisation is also of importance in mild steels below the critical range. Intercrystalline cracking is encountered principally in tests of Armco ingot iron. Recrystallisation in creep tests proceeds by a continuous action accompanying the deformation and is most prominent in places of maximum deformation.

The Penetration of Molten White Metals into Stressed Metals.

This paper, by Mr. W. E. Goodrich, describes the results of an investigation carried out to ascertain the effect of variations in temperature, rate of application of stress, mechanical properties, microstructure, and chemical composition on the resistance of stressed steels to the penetration of molten white metals. It was found that premature failure only occurred when the samples were stressed in tension in the presence of molten white metals, and that resistance to penetration decreased with rise in temperature and with slower rates of loading.

Consideration of the test results on carbon, nickel, nickel-chromium, nickel-chromium-molybdenum and austenitic steels, tested at 250° C. and 350° C., led to the conclusion that the static tensile properties were no absolute indication of the interpretation-resistant properties. The addition of nickel up to 1.2%, at least, to carbon steels was deleterious at both temperatures, whilst the addition of molybdenum to nickel-chromium steels appeared to confer no marked advantage.

The microstructure of the material constituted the main factor influencing the resistance to interpenetration. With carbon and nickel steels the presence of free ferrite was a distinct advantage at 250° C., particularly when in the form of a network, but at 350° C. increased amounts of free ferrite were of little benefit. With reference to nickel-chromium and nickel-chromium-molybdenum steels, the presence of intermingled ferrite was again advantageous at the lower temperature. At 350° C., however, there appeared to be an optimum amount of intermingled ferrite which was of advantage, the presence of ferrite in excess of that optimum quantity reducing the resistance of the alloy steels to interpenetration. One of the nickel-chromium steels with a microstructure consisting of small-grained compact sorbite and a small amount of intermingled ferrite, showed remarkably good penetration-resistance at both temperatures.

The effect of grain-size was very marked, small grain-size being beneficial, particularly at 250° C. Temper-brittleness appeared to have no effect on the resistance to interpenetration.

The Piobert Effect in Iron and Soft Steel.

When a highly-polished bar of soft steel is subjected to increasing tensile stress, a value of the stress is reached at which the bar may suddenly yield to a remarkable amount with permanent surface distortion easily recognised as characteristic. The distortion is called the Piobert effect. Doubt exists as to whether the effect is observed other than in iron and soft steel, and this paper by Dr. Ing, E. W. Fell summarises as much relevant data as are obtainable for the purpose of removing uncertainty.

The effect seems a property of an aggregate of iron crystals, and is ordinarily not observed with other steels, non-ferrous metals, and non-metallic solids. The spread of the effect is compared with the yielding process. Its spread throughout the bar is progressive, and occurs at nearly constant stress. It may thus be compared with the spread of solidification at constant temperature in a mass of pure metal about the melting point. A phase change is considered.

The distortion, analysed with ruled testbars, may be represented as successive slips of layers or planes of particles over one another. Such a layer comprises many crystals. A distorted domain is divisible into smaller domains in each of which slip may be one of two kinds. In the simpler kind the slip seems constant in magnitude and direction. in the other kind the magnitude of the slip in a certain direction varies. The resultant slip is generally not parallel to the surface of the rectangular testbar. The change in the shape of the testbar, after removal of the stress, may be regarded as the sum of the changes in the smaller domains. The distortion results from shear. Propagation of the effect is probably due to stress concentration. There is some similarity to distortion in a single crystal.

The Properties of some Low-Nickel Steels Containing Manganese.

The mechanical properties of steels containing 0.3% to 0.4% carbon, 0.7% to 1.35% manganese, and 0.5% to 2.0% nickel have been examined, the results of which are given in this paper by Dr. R. H. Greaves, and it is found that a steel, in the normalised condition, containing 0.35% carbon, 1% manganese and 1% to 1.5% nickel gives good mechanical properties, better than those previously obtained from 3% nickel steel, 1.4% manganese steel and silico-manganese high elastic limit steels.

Steels of approximately this composition do not harden fully when quenched in oil in sections $\frac{3}{4}$ in. thick, and are subject to mass effect, but their mechanical properties in the oil-hardened and tempered condition are equal to those for which 3% and 4% nickel steels of similar carbon and low manganese contents are frequently employed.

An increase in manganese and nickel, either separately or together, within the limits investigated, diminishes the mass effect, and leads to an improvement in the mechanical properties without serious loss of ductility. It also increases the range of temperature from which quenching may be carried out without adversely affecting the mechanical properties. Steels of the higher manganese and nickel

contents are susceptible to temper-brittleness, but air-cooling of sections ¾ in. thick does not give rise to a low impact figure. All the steels investigated hardened fully on water-quenching, and the relatively high manganese content of some of them did not result in any cracking.

It would appear that, in suitable circumstances where a yield point of over 32 tons per sq. in. is required, with maximum load over 45 tons per sq. in., and impact figure over 40 ft.-lb., oil-hardened and tempered steels containing 0.35% to 0.40% of carbon and 1.0% to 1.3% of manganese with about 1% of nickel may be used with economic advantage in sections up to 2½ in. in thickness in place of 3% nickel steel. If a high impact figure is required, and the section to be treated exceeds 2½ in. in thickness, it may be necessary to reduce the carbon to 0.30%, and increase the nickel to 1.5% or even 2.0%, since steels with the higher carbon content indicated above, when treated in large sections, give an impact figure below 40 ft.-lb.

Subcutaneous Effects During the Scaling of Steel.

Modern requirements of surface finish on steel products have necessitated the closest attention being paid fo causes of minor defects. This applies particularly in the tinplate industry, where the need for economy has resulted in the thickness of the tin coating being cut down to the minimum commensurate with adequate protection. In this and other fields, minor subcutaneous changes in the structure and composition of the articles during heat-treatment may be reflected in the properties of the finished products—in particular, a decreased resistance to fatigue and corro-ion may result.

This paper, by Mr. M. Griffiths, deals with subcutaneous changes which have been observed during the oxidation of various steels in the laboratory, but which may prove of industrial interest. The author advances an explanation for the formation of globules and spots below the steel surface when oxidising under certain conditions, and states that the more oxidisable elements contained in the steel the greater is the extent of precipitation and formation of globules and spots, so that where a specially good surface is required the steel should contain a minimum of elements having a high affinity for oxygen—that is, any excess of deoxidising agents, such as aluminium, etc., should be at a minimum. Unless the affected area is removed completely, the effects of the phenomena on a steel intended to be fatigue-resisting may be to initiate surface cracks.

Examination of the Surface of Tinplate by an Optical Method.

The usual hot-dipped tin coating on steel is extremely thin, and methods of examination involving sectioning the edge at right-angles are not sufficiently convenient to be generally applicable. In this paper by Mr. W. E. Hoare and Dr. Bruce Chalmers, the surface of tinplate has been examined by an optical method involving the formation of interference fringes between an optical flat and the tin surface. The method enables a distinction to be made between hollows and reliefs in the surface, and the depth of an irregularity is easily determined by counting the fringes under visual observation.

Sections of the more significant surface irregularities have been plotted on an enlarged scale. The authors point out that the method would appear to be applicable to the study of the surface contours of hot-dipped, electro-deposited and other coatings.

The Behaviour of Mild Steel Under Prolonged Stress at 300° C.

PART II.—EXPERIMENTS ON CONCENTRATED STRESS IN NOTCHED AND DRILLED SPECIMENS.

This paper by Dr. C. H. M. Jenkins, which summarises an investigation of the Metallurgy Research Board of the Department of Scientific and Industrial Research, is devoted to the study of localised stress produced by the use of notches and drilled holes in similar strip specimens. The experiments described form a continuation of a previous set of experiments on the behaviour of mild steel in regard to the possibility of cracking under the action of prolonged stress at 300° C.

Although considerable deformation has taken place around the holes and notches inserted in the specimen, the author states that failure by cracking has not been produced under a stress similar to that of the yield point. It would appear that concentration of stress, cold work and a temperature of 300° C. are not sufficient to bring about failure, and that tests with chemical accelerants are desirable.

The Distribution of Phosphorus Between Metal and Slag in the Basic Process of Steel Manufacture.

The division of phosophorus between the slag and the steel in the processes of manufacture can be referred to certain laws of equilibrium; in the laboratory various means have been worked out for proportioning the phosphorus accordingly, but the direct application of these researches to practice has been lacking. In this paper by Messrs. E. Maurer and W. Bischof, the author presents an interpretation of analyses derived from practical operation and links them up with experimental work described in an earlier paper* in an endeavour by this means to determine the respective influence of the steel and the slag components on the distribution of phosphorus in steel manufacture by the basic process.

From melting tests, the laws of the distribution of phosphorus were established, first in outline and then in relation to the presence of pure iron phosphate slags, confirming the author's earlier conclusion that where the phosphorus contents of the iron and the slag are low the distribution at any given temperature is invariable. Further a certain temperature relationship was established. Additions of silica to the slag were found to cause a reduction of the ratio of distribution $V_P = (P_2O_5)/P$.

Next, in order to study dephosphorisation in the process of steel manufacture, the effect of changing proportions of manganese in the steel was determined by curves and was shown to be important, an increase in the manganese while the composition of the slag remained constant resulting in an increase in the phosphorus content of the steel. The lime content being altered only by small steps, the ratio of distribution V_{P_0} as governed by the amount of silica was determined by convergence. It was found that the values of V_{P_0} increased with increasing amounts of lime, and that the effect of the latter was diminished by the silica. A fundamental diagram was compiled enabling the phosphorus content of the steel to be theoretically determined for any given composition of slag and procedure in steel making.

The temperature relationships of the slags occurring in practice were found to correspond completely with those established for pure iron phosphate slags. As the temperature rises dephosphorisation is rendered less effective—a fact already recognised qualitatively. Within the limits of the slags met with in operation, manganous oxide and magnesia are without effect on the distribution of phosphorus. Alumina has an unfavourable effect on the ratio of distribution, which is exercised in the same direction as is the case for pure iron phosphate slags.

Morphology of the Inclusions in Siderurgical Products.

This paper, by Professor A. M. PORTEVIN and RENE CASTRO, is a review of the morphological aspects of the non-metallic inclusions, of which it demonstrates the multiplicity, even when observations are confined to the

(*Continued on page* 156.)

* W. BISCHOF and E. MAURER: *Archiv fur das Eisenhuttenwesen*, 1932-33, vol 6, pp.415-421.

The Shipping, Engineering, Machinery and Foundry Trades Exhibition

This Exhibition is more representative of the various industries included than the last, held under similar auspices two years ago, and visitors may be assured of seeing much of interest and value. In this review it is only possible to indicate some of the outstanding features in order that it may serve as a guide.

HELD under the patronage and active support of several Associations, this Exhibition is admirably supported by all the sections of industry represented, and is much in advance of the last effort held under similar auspices. The Exhibition, which continues until September 28, was officially opened at Olympia on September 12, by Lord Sempill. In the course of an address, delivered to a representative audience, he stressed the coming of the compression-ignition engine as the most notable development in road transport. The use of this engine offered advantages from the standpoint of safety, and now that commercialised aircraft were regularly flying long distances with heavy loads the economy in fuel consumption was an important factor. The advantages of engines of this type were apparently recognised, he continued, since the latest flying boats now being prepared for the South Atlantic air mail services were being fitted with them.

Lord Sempill commented favourably on the display of metallurgical products in the Exhibition and spoke of the progress of this branch of industry. He especially mentioned the display of foundry equipment, and suggested that a study of this section would show the considerable advances made in recent years. He referred particularly to cast iron which, after suffering neglect for a century, had, under the stimulus of the British Cast Iron Research Association, been receiving the attention its qualities merited, and with the knowledge made available further progress was assured. In other ferrous and non-ferrous materials research continued and, though there had been no sensational developments during the past two years, it was providing a degree of knowledge of alloys which held incalculable possibilities. Commenting on the excellent progress of the Exhibition, Lord Sempill stated that much of the progress was due to the able work of Dr. H. S. Hele-Shaw, the chairman of the Honorary Committee of Experts.

To the visitor the exhibits are set out in a most attractive manner, and it is noteworthy that firms exhibiting recognise the value of technical experts in discussing the relative merits of their products; in the majority of instances visitors may be assured that their particular problems can be discussed with experts and with every likelihood of reaching a satisfactory issue. The real object of Exhibitions of this character is to bring together evidence of progress in production and manufacture and improved technique in the application of the products in order that the time lag between a development and its complete application in industry may be reduced to the minimum. Those anxious to keep in line with progress will find much of interest and will be well repaid for a visit. In the notes brief reference is made to some of the interesting exhibits.

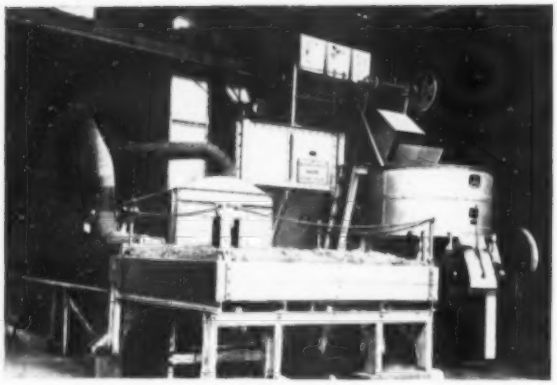
Tinning a large vat with the metal-spraying piston developed by British Oxygen Co., Ltd.

Sir W. G. Armstrong-Whitworth and Co. (Ironfounders), Ltd.

The range of Armstrong-Whitworth Special "New Process" pig irons show admirably the improvements that can be made in giving higher strengths, greater resistance to wear, and perfectly homogeneous castings free from porosity and shrinkage. Fractures of various grades are shown, each suitable for certain purposes. Castings made from these irons are exhibited, and vary from a locomotive cylinder weighing 1½ tons to light green sand castings of a few pounds. These exhibits show that this pig iron is being used for work in all classes of industry, and is specially suitable for internal-combusion engine and high-duty castings.

The introduction of chilled cast pigs is worthy of notice, and a stack of chilled cast iron is laid side by side with sand-cast iron, so that foundrymen are able to judge which is most suitable for their purpose. Alloy pig iron containing nickel, chromium, copper, molybdenum, etc., shows the progress that has been made in meeting the requirements of the most scientifically controlled foundries.

Attention is particularly directed to the "Closeloy" alloy heat treated roll exhibited, which illustrates a type that is being widely used for the rolling of medium and fairly heavy sections, including the roughing and finishing of rails, channels, joists and angles. Of high strength and showing great resistance to wear and fire-cracking, considerably increased tonnages per dressing are obtained without detriment to the finish on the product rolled. By slight modifications to analysis and heat-treatment, different grades of roll can be produced to meet the requirements of varying conditions.



No. 2 size August's composite sand plant.

AUGUST, LTD.

This firm of foundry equipment designers and manufacturers exhibit an August's Simpson sand mixer capable of preparing moulding sand at the rate of 30 tons per hour. This machine incorporates the latest developments and a large number has been installed. A small laboratory mixer of this type is also exhibited. The range of foundry plant built by this firm is very considerable, and for convenience scale photographs display August's composite sand plants which embody the August's Simpson sand mixer as the sand-mixing unit. These composite sand plants are built in sizes covering outputs of from two to 15 tons per hour of iron foundry facing sand, and are quite complete units for the reclamation of used foundry sand. In these plants the used foundry sand is cooled, oversize and foreign matter removed, iron and silt extracted, and this cooled, cleaned and iron-free sand is used as a basis from which to prepare at will any type of foundry-sand mixture that may be required.

These plants are universal in their application, can be used in any type of foundry, either iron, steel or non-ferrous, and can be used to prepare any type of facing sand, loam, core sand or merely to recondition backing sand. Together with this exhibit are shown a number of samples of the foundry sand at various stages of the process giving a very clear idea of the operation and principle of the plant. Other large-scale photographs illustrate August's mechanised core shops and show the latest developments in automatic sea-sand drying, screening, cooling, and core sand-mixing plants, together with core-blowing machines and core-drying plants.

BIRMINGHAM ELECTRIC FURNACES, LTD.

Three main features are represented in the exhibits of this company: melting furnaces, heat-treatment furnaces, and informative data. A noteworthy exhibit is a small model of the Birlec-Detroit furnace This is a rocking arc electric melting furnace which has proved very effective for melting brass, bronze, and similar metals, while it is also adopted with complete success for the melting of special high-grade cast iron and alloy iron of various types. This furnace operates with a strongly reducing atmosphere, so that metal losses are negligible, and a further economy may be effected by melting charges of cheap scrap for the production of high-purity metal.

A general purpose heat-treatment installation suitable for carburising, reheating, annealing and general heat-treatment work is on view. The heavy heating elements and the method of mounting them are noteworthy features of this furnace. In addition to the foregoing exhibits, attention is directed to a range of photographs, coupled with detailed technical data, which illustrate the entire field of this company's activities in the heat-treatment and melting spheres. The special processes covered include bright annealing, brazing, nitriding, heat-treatment of aluminium alloys, tempering, etc., and a number of mechanically operated furnaces—*i.e.*, with some form of conveyer mechanism for the material—are included amongst the illustrations.

BRADLEY AND FOSTER, LTD.

This firm's exhibits comprise a range of fractures of pig irons, including cold blast and cylinder qualities, degasified pig irons, chromium pig irons, nickel and nickel-chromium irons, molybdenum irons, copper and tungsten pig irons. It specialises in the production of refined and refined alloy pig irons in a large variety of grades for use in the production of high-duty castings, and composition is guaranteed within very close limits and uniform throughout each consignment. A patented process for degasifying the metal is used during manufacture of the pig iron to ensure the best casting properties on remelting.

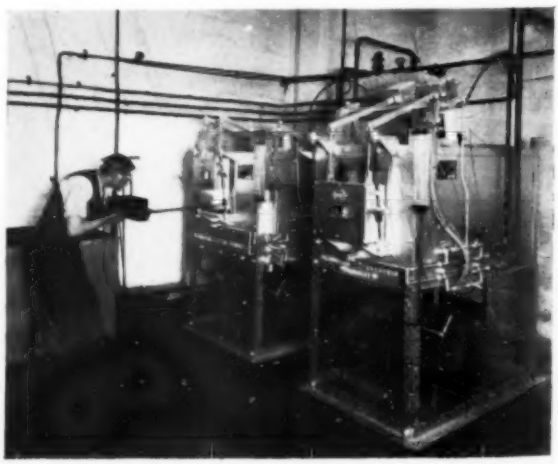
This firm also display chilled-steel abrasives used in the sand-blasting of castings, in vitreous enamelling, in the stone-cutting, glass-making and well-boring industries. In addition to the foregoing, it is noteworthy that an important section of this firm's activities lies in the commercial heat-treatment of steels, cast iron and alloys. All classses of heat-treatment work are undertaken, including case-hardening, oil hardening and tempering, air hardening, annealing, stabilising, age hardening of aluminium alloys, and hardening and temperang cast iron. Nitrogen hardening is also carried out in the latest types of electric resistance furnaces, and the firm are the authorised district licensees for the nitrogen hardening process.

THE BRITISH OXYGEN CO., LTD.

In addition to a comprehensive display of high- and low-pressure oxy-acetylene outfits for welding metals and for cutting steels, cast and wrought irons, this company show oxy-coalgas and air-acetylene equipment for brazing, melting, surface heating, soldering, paint-burning, and lead-burning, as well as blowpipes for glass-working.

For many purposes oxygen machines give several advantages, and in the 55-in. machine exhibited engineers have the opportunity of inspecting a precision machine comparable to a machine-tool, which is capable of producing parts of any shape which can be inscribed in a semi-circle of 55-in. radius from steel plate or forgings 14 in. thick and over. Some small portable power-driven types are also exhibited. Included in the exhibits are ferro-arc electrodes specially suitable for shipbuilding and structural steel work, and a 250-amp. single operator motor generator set. A new exhibit of special interest is the British high-speed metal spraying unit.

"Certain Curtain" furnaces by Birmingham Electric Furnaces Ltd. for scale-free preheating and hardening of high-speed steel tools.



THE BRITISH CAST IRON RESEARCH ASSOCIATION.

The exhibits by this association show the remarkable developments effected in the production of castings during the past few years. Of special interest among the exhibits is an elutriator, which is used in separating the various particle sizes in mouldings and. It is necessary, of course, when examining the moulding sand to have some idea of its grading, and this elutriator is the one most commonly used for this purpose. Samples of 3-in. diameter cast-iron bars are shown, in which the structure has been modified by means of a method recently evolved. This structure modification results in a much closer iron being obtained, and also a much stronger one. For instance, the transverse rupture stress of a bar without alteration in chemical composition has been increased from 20 to 27 tons per square inch.

BRITISH PIGIRONS, LTD.

Representative examples of "Midhill" and "Glenhill" Allmine special pig irons are shown, together with fractures test-pieces, microphotographs, etc. This firm claim to be the pioneers in Great Britain in supplying pig iron to definite guaranteed analysis coupled with the appropriate fracture. The above brands are smelted at their associated works in Scunthorpe, Lincolnshire, and are to be found in regular use. These popular brands are produced in cylinder, chilling and special foundry qualities and, owing to the diversified analysis of the stocks carried, the firm are in a position to give prompt delivery of pig iron to almost any practical specification in these grades. It should be particularly noted that the pig irons exhibited are guaranteed blast-furnace products, and are not refined or subjected to any secondary heat-treatment.

BRITISH COMMERCIAL GAS ASSOCIATION.

A really representative collection of gas appliances is on view, and actual demonstrations are carried out in most instances. The main exhibit is an extensive heat-treatment shop in full working order. Demonstrations are given with oven and muffle furnaces of various types and sizes at all temperatures up to those used for the hardening of high-speed steel. In addition to an ordinary high-speed steel furnace, one fitted with the Sheffield patent atmosphere control is shown. A range of metal-melting furnaces is on view, and a plastic moulding press and a press for hot brass stampings are shown at work. Other working exhibits include an oxy-coal-gas profile-cutting machine, metal-spraying pistols, automatic gas engine-driven generator sets, a degreaser, a series of glass-blowing burners and a range of drying ovens. The application of gas is now so universal that every manufacturer will find something which is applicable to his processes.

THE INTERNATIONAL MEEHANITE METAL CO., LTD.

Meehanite metal is a cast ferrous material controlled to meet definite service requirements, and possesses superior physical properties to cast iron and semi-steel. It has replaced steel, manganese steel, and malleable cast iron, and finds many applications where severe service conditions exist (*e.g.*, miscellaneous dies, rock crushers, cement plants, dredger and pump parts, etc.). It is manufactured by several foundries in this country under licence, and a comprehensive exhibit of castings has been arranged with special reference to high-duty parts. The suitability of Meehanite metal for this purpose is shown by a number of camshafts and crankshafts of heat-treated Meehanite supplied to prominent automobile manufacturers. Dies cast to a file finish (*i.e.*, no machining is necessary), cylinder liners, gears, pump parts, laundry machinery parts (replacing malleable cast iron), goosenecks, brake drums, pipes 20 ft. × 4 in. diameter (for sewage), castings for cement plants, rock crushers, cement mixers and parts produced by continuous casting plant, show the wide adaptability of the material, which is finding an increasing demand in all industries.

Vibratory chute pattern magnet by Electromagnets Ltd., suitable for extracting tramp iron or fine iron from ore, fuel, casters' ashes and scrap in bulk quantities.

THE CARBORUNDUM CO., LTD.

This company displays a comprehensive range of Carborundum brand refractories, including: Carbofrax and Alfrax bricks, tiles, special shapes, tubes, muffles, Carborundum brand crucibles, firesand and cements. Carborundum is a super-refractory material, produced in the intense heat of the electric furnace, which cannot be melted, and which possesses an extremely low coefficient of expansion coupled with high thermal conductivity. Carbofrax will withstand the highest temperature, resist abrasion, and does not spall or crack under rapid changes of temperature. Alfrax bricks are principally composed of electrically-fused alumina ("Aloxite").

Carbofrax and Alfrax enamelling muffles are a most economical proposition: they have the advantage of long life with low fuel consumption, giving increased production at low burning costs, and with a uniform distribution of heat. In the form of hearth tiles for heat-treatment furnaces, these brands of refractories will stand up under the trying conditions of heat-treating heavy articles, show remarkable resistance to abrasion, and will not soften nor sag.

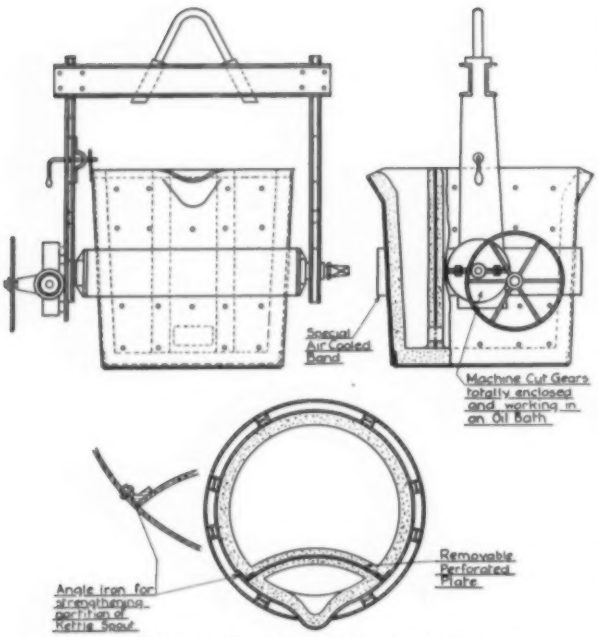
Designed for the melting of ferrous and non-ferrous metals, Carborundum crucibles possess many advantages, such as long life, no annealing treatment required (as they do not absorb moisture), withstand unlimited heat, and are not affected by being cooled between heats.

ROBERT W. COAN, LTD.

A comprehensive range of aluminium sand castings is exhibited by this company, which includes various castings to many "D.T.D." an "L." group specifications, gravity die-castings in aluminium, and castings in "Coanailium," a special alloy with corrosion-resisting properties which is used for all classes of marine work and parts that are exposed to atmospheric and climatic conditions. The majority of castings are shown in the as-cast condition, but representative examples show a high-class polish finish.

COLVILLE'S, LTD.

Samples of the well-known brands of pig iron made by this firm are exhibited, including Dalzell, Glengarnock, Clyde and Monkland foundry qualities and Clyde Special



Sections and elevation giving details of a kettle spout ladle suitable for the treatment of cast iron by sodium carbonate.

and Ordinary hematite. These will be in the form of pigs as cast. A series of fractures show No. 3 Clyde, No. 3 Glengarnock, No. 1 and 3 Dalzell Special Low Phosphorus, No. 4 Close Dalzell Foundry qualities, Clyde Hematite and Clyde Basic. Sample pigs and fractures of Dalzell Special Refined Pig Iron, the special feature of which is its low carbon content, this being 3% maximum. This iron is extensively used for the manufacture of high-duty castings. Several specimens of castings made from mixtures of these irons are also shown.

THE CALORIZING CORPORATION OF GREAT BRITAIN, LTD.

The exhibit of this company comprises heat-treatment containers for case-hardening, cyanide, salt and lead hardening, both in calorised pressed-steel construction, and in cast "Calmet" heat-resisting alloy, together with calorised solid drawn steel pyrometer sheaths. Further, a small section of a roof hanger assembly for oil-cracking stills is shown in which the tubes are supported by means of hangers from the roof, the tubes being of calorised weldless steel, and the hangers in "Calmet" heat-resisting alloy. Photographs of various applications of the calorising process are shown, and articles in "Calmet" alloy, including Calorized Calmet, which is so successful for conditions where highly sulphurous gases prevail.

THE CONSTRUCTIONAL ENG. CO., LTD.

Amongst the many exhibits of this company is the bottom part of a "Titan" cupola, designed to melt four to five tons per hour. This cupola embodies developments which are exclusive features of the "Titan." A small self-contained melting unit, made in capacities of 10 cwt., 15 cwt. and 20 cwt. per hour, is also on view. A noteworthy exhibit is known as the sand wizard : this sandblasts castings, forgings, etc., without the use of compressed air, and is claimed to reduce power consumption by 80% to 90%, and yet improve the quality of work done in reduced time. Many additional exhibits are of special interest to the foundryman, and should be inspected.

ELECTROMAGNETS, LTD.

A comprehensive range of equipment and appliances is shown by this firm, which makes a speciality of magnetic separators and equipment. Many types of separators are shown, such as are used for extracting ferric material in various forms, powders, liquids, plastic and lump materials, with a view to purifying foodstuffs, etc., and also preventing damage to pulverisers, crushers, grinders, handling plant and the like. Lifting magnets of all types are also shown ; these are designed for handling magnetically scrap pig iron, skull cracker balls, ingots, moulds, sections, sheets, etc., in the steelworks, foundries, rolling mills and scrap yards.

Special magnets for use in conjunction with shear tables and rotary skid magnets are also exhibited. Magnetic chucks of all types, including plain-faced, rectangular, circular, swivelling and taper-faced designs for holding steel components during machining operations such as grinding and shaping.

THOS. FIRTH AND JOHN BROWN, LTD.

The exhibits by this company cover a wide range of specialised products, such as high-pressure hollow-forged drums for marine purposes, turbine rotors and wheels, shafting, crankshafts, and a typical range of special alloy castings for turbine casings and ships' castings generally. In addition, there is a complete demonstration of the firm's products of engineers' small tools, including those tools specially used by the shipbuilding and engineering industries. Of considerable interest are the high-speed steels and alloy steels shown.

THE FIRTH-VICKERS STAINLESS STEELS, LTD.

This exhibit is especially noteworthy, showing, as it does, the remarkable progress in the application of stainless steels, more particularly the range of applications of Firth-Vickers Stainless and Firth-Vickers "Staybrite" Super Rustless Steels to the shipbuilding industry. Attention is directed to their use for such purposes as turbine blading, marine valves, deck and cabin fittings, and interior decoration. A complete range of this firm's heat-resisting steels for furnace components and other purposes is also shown.

THE FORDATH ENGINEERING CO., LTD.

The exhibits of this firm are of special interest to foundrymen, and include large and small sizes of the latest rotary core machines together with typical cores made from them. These, together with a series of "Rotoil" sand mixers, show that precision machine tools can be applied with advantage to the work in the foundry. Samples of parting sand, core and mould spraying solutions, mould dressings and special refractories are shown, all of which are prepared by this firm. The well-known "Glyso" core compound should not be overlooked, and advantage should be taken of this firm's advice and assistance in overcoming foundry problems.

GENERAL REFRACTORIES, LTD.

The exhibits include specimens and demonstrations of most of their materials. Special mention should be made of the complete range of foundry sands. Among these are Bramcote, Levenseat, York Yellow, Hollinwood, Red Rover, Thanet, Zenith, Pickering, Harperley moulding sands, and K.L. Minimum, Maximum core sands, etc. Yorkshire sand, the well-known steel moulding sand, is also exhibited. Of particular interest to steel founders is a recent introduction in "Chamotte" moulding compositions. With these materials it is claimed that heavy steel castings may be produced more economically and with better finish.

Firebricks of all types are shown, and perfection in shape and size indicate the extreme care taken in this matter, which in modern furnace construction is of vital importance. Specimen sleeves, nozzles and stoppers are exhibited, together with cupola linings, boiler-furnace linings materials, etc.

CHARLES HEARSON AND CO., LTD.

Reichert metallurgical microscopes are exhibited by this firm, and they include the Reichert universal camera microscope, "M.e.F."—a combined bench instrument

adapted for direct observation and photomicrography, and under all kinds of illumination in transmitted and reflected light; Reichert large metallurgical microscope, "M.e.A.," which is an advanced design of the well-known "E.M.I (Le Chatelier) type. The "M.e.A." embodies the optical construction of the "M.e.F.," permitting bright and dark field illumination with ordinary and polarised light. The instrument is adapted for direct visual observation, microphotography and macrophotography, Reichert metallographic microscopes, workshop microscopes and Brinels Hearson small metallurgical bench microscopes. In addition, this firm exhibit tube and muffle types of electric furnaces in conjunction with temperature-recording equipment up to 1,000° C.

Heatly Electric Forgings, Ltd.

In this instance the exhibits include a range of electrically upset forgings, which show many advantages over forgings produced by ordinary methods In many cases machining can be entirely eliminated, since the main part of the forgings is bright drawn-bar stock, and can be given to limits of a few thousandths of an inch, or may be centreless ground to exact limits before being used for the process. Electrically upset forgings of this type possess great strength, seeing that the grain flow is correct

High Duty Alloys, Ltd.

As is well known, this firm manufacture the "Hiduminium" R.R. series of high-tensile aluminium alloys, and examples of these materials in the form of castings, forgings, stampings, tube, sheet, bar, and extruded sections prove most interesting. These alloys are being applied to a wide range of uses where strong, light alloys are needed. Included in the range of alloys is "Hiduminium" R.R. 66, which possesses excellent non-corrosion properties, and which is available in cast and wrought forms.

Imperial Chemical Industries, Ltd.

Of particular interest among the exhibits of this company are the sodium carbonate and fused sodium carbonate blocks for the refining of cast iron and non-ferrous metals. Sodium carbonate has a number of beneficial effects on cast iron, among them being degasification of the metal, refining of the graphite, removal of non-metallic inclusions and reduction in sulphur content. The last of these is of particular value in connection with steelmaking. In the case of iron castings, the use of this chemical results in the production of sounder castings, free from porosity, and having better machining properties. It also frequently makes it possible to use a cheaper mixture in the cupola. Sodium carbonate is also used as a flux in the melting of brass swarf, where it prevents loss of zinc by volatilisation, and removes entrained oxides and other non-metallic inclusions. It also finds application in the modification of aluminium silicon alloys.

Mond Nickel Co., Lvd.

The exhibits of this company comprise a varied selection of applications of nickel steels, light alloys containing nickel, nickel cast iron, nickel iron and nickel non-ferrous alloys. A comprehensive range of literature on the properties and applications of nickel and its alloys is displayed, while technical representatives give advice and assistance in connection with any problems involving the use of these materials.

The Morgan Crucible Co., Ltd.

Salamander and Salamander super crucibles form an imposing exhibit. These, together with stands and muffles, are used in the melting of a wide range of metals and alloys. Tilting and lift-out crucible furnaces, for use with oil and coke fuel for all metals, are also shown. In addition, a range of the grades of firebrick is included. These are manufactured at the works of an associated company, The Douglas Firebrick Co., Ltd., Dalry, Ayrshire—"Douglas," "Douglas A," "D F C," with special materials

Large Deisel engine piston in Hiduminium Alloy by High Duty Alloys Ltd.

such as "Triangle W" (non-spalling fireclay), "Triangle V" (52/54% Alumina), "Triangle V 5" (Sillimanite), etc. The shapes show the application to suspended arches and walls, heat-treatment furnaces, cupolas, and other types of furnace settings.

Special refractories manufactured at Battersea are also shown, for example, "Triangle C C" (Silicon Carbide), "Triangle V 55" (Fused Alumina), with illustrations of the application to enamelling furnaces, while there is a representative range of ware for which the company has been well known for many years—namely, clay crucibles, muffles, scarifiers, refractory tubing, etc.

Sheepbridge Stokes Centrifugal Castings Co., Ltd.

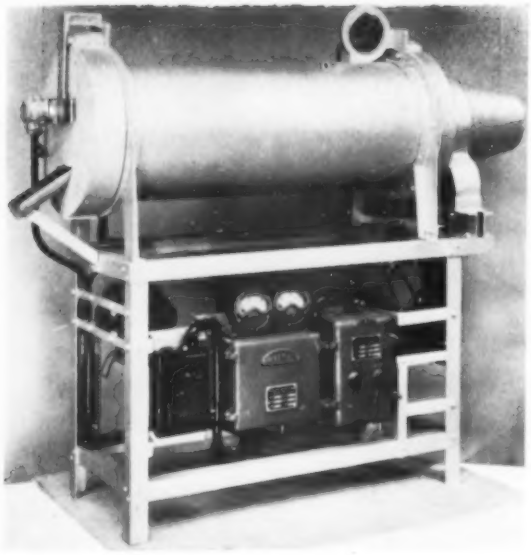
Typical components in special alloy cast irons, manufactured either by this company's centrifugal process of casting, where cylindrical shapes are required, or as sand-castings for more complex shapes, are shown. Amongst the more important of these special irons are the following:—"Centrard" (nitrogen hardened) for abrasion and corrosion resistance. Brinell hardness, 900 to 1,000. "Hypocrode" for corrosion and heat resistance. "Nicrosilal" and "Silal," for resistance to heat and scaling. "Centricast Mark II" Chrome alloy for wear resistance, suitable for oil hardening where thin sections are required. "Centricast Mark IV" nickel chrome alloy for wear resistance and high strength, suitable for oil hardening where thick sections are required. "High Silicon," for acid resistance.

Stewarts and Lloyds, Ltd.

This firm show a comprehensive range of samples of pig iron manufactured at their various works, and also samples of pig iron manufactured by the Ford Motor Co., Ltd., for whom they are sole agents. A selection of castings is shown demonstrating typical uses for the various grades of iron. Of particular interest is a set of three springs cut from pig iron and arranged in a working model to show the flexibility of the iron. It is interesting to note that each of these springs has performed over 250,000 cycles of extension and compression without fracture.

Tensometer, Ltd.

Several examples of two types of the Hounsfield Tensometer are exhibited. One type has been on the market for



A continuous-draw annealing furnace by Wild-Barfield Electric Furnaces Ltd.

some time, and the other type is being exhibited for the first time. The new type machine has the well-known features of the first in using small test-pieces and in yielding results from them which are as reliable as those from standard test-pieces in one-purpose machines ; and like its companion, the new machine makes not only tensile tests, but notched-bar tests, bend tests, strip tests, tests for Brinell hardness.

The new type machine, being differently arranged, has a much larger autographic record. It can be used for tensile test-pieces of considerably greater length than those accommodated in the present type of machine, and is also able to provide tensile tests for wire, allowing a length up to 14½ in. between the wire grips.

THE UNITED STEEL COMPANIES, LTD.

A comprehensive range of products exhibited include pig irons on behalf of the firm's Workington Iron and Steel Branch. These comprise hematite pig irons, refined pig irons for malleable castings in various grades, "Uco" All-Mine pig irons and "Uco" cylinder irons. These latter are becoming increasingly in demand by foundrymen and engineers, because they find in "Uco" cylinder irons the regular quality and consistency which are so valuable. In addition to showing actual pigs, the firm show a selected range of the applications of these irons. An associated company, Appleby-Frodingham Steel Co., Ltd., show plates and examples of the uses of plates in connection with shipbuilding.

WILD-BARFIELD ELECTRIC FURNACES, LTD., AND G. W. B. ELECTRIC FURNACES, LTD.

Many forms of heat-treatment plant and hardening-shop materials are shown by these firms. A rotary drum type furnace, used for annealing ferrous and non-ferrous materials, and hardening and normalising steel components, is in operation. Whilst this type has hitherto been mainly used for large-scale production, the exhibit shows one suitable for the usual outputs of small components. Hardening furnaces for carbon low alloy and carburised steel, fitted with the Electro-magnetic Indicator, "Heavy Hair-pin" heat-treatment furnaces and high-speed steel-hardening equipments are represented. The latest form of atmosphere control, giving reliable furnace atmospheres with the simplest equipment is a prominent feature on these furnaces. For tempering, secondary hardening of high-speed steel, the heat-treatment of aluminium alloys, forced-air circulation furnaces are in operation.

Soviet Metallurgy Masters Technique of Production.

By A Special Correspondent.

A REVIEW of the work of Soviet heavy industry for the first six months of the current year shows that the total output was greater by 2,231 million roubles than the output for the corresponding period of last year. The proportion of this increase attributable to the increase in the number of workers employed in heavy industry is reckoned at 744 million roubles, the remainder being due to the steady increase in the productivity of labour. One thousand five hundred million roubles of the increased output in the first half of this year is attributed by Soviet authorities to the improved technical skill of the workers employed in heavy industry. By raising their technical knowledge and improving their qualifications they have achieved an increase in the productivity of labour.

Stalin, in a recent address, said: "It is now admitted that we already have a powerful, first-class industry, a powerful mechanised agriculture, a growing and improving transport system. . . . This means that we have in the main outlived the period of famine in technical resources." In this connection Stalin put forward the very important task of creating staffs of workers capable of mastering and utilising this technique according to all the rules of the art.

Considerable achievements are recorded in the fulfilment of this task. Quite recently the Commissariat of Heavy Industry reported that 850,000 workers in heavy industry had passed technical examinations. Undoubtedly, the increasing of the workers' technical knowledge and raising their qualifications has been responsible for the fact that the productivity of labour has risen by 15.5% over that of last year, and by 1% more than was provided for in the annual plan.

The most vivid example is presented by metallurgy which, during the first six months of this year, has increased its output over the same period of 1934 by 29%. A considerable share of this increase is due to the rise in the productivity of labour, resulting from the workers' greater skill in the technical processes. An increase of 10·5% in the productivity of labour in 1933, of 26·5% in 1934, and of 18·4% in the first half of the present year—such are the achievements of the Soviet ferrous metal industries.

There has also been a large increase in the productivity of labour in other branches of Soviet industry. In the non-ferrous metallurgical industry it amounts to 46·2% over last year ; in the chemical industry 31% ; in machine building 16·4% ; and in the iron-ore industry 26%.

Metropolitan-Vickers Electrical Co., Ltd.

The London Office and the offices of the Export Company of the above firm have moved from Bush House and the London address is now Number One Kingsway, London, W.C. 2. The telegraphic address is "Multiphase, Estrand, London," while the telephone number remains unchanged.

In addition to the usual features, the July issue of The Nickel Bulletin contains interesting articles on "Non-Magnetic Cast Iron in the Electrical Industry" and "Nickel Containing Bronzes in the Automobile Industry." Copies can be obtained from The Bureau of Information on Nickel, The Mond Nickel Co., Ltd., Thames House, Millbank, London, S.W. 1.

Personal

Mr. A. Glynne Lobley, General Manager of Messrs. Birmingham Electric Furnaces, Ltd., left on a business trip to the United States on September 18. He will take the opportunity of renewing direct contact with the Company's American Associates.

Mr. A. E. Rhoads, Vice President and chief technical expert of the Detroit Electric Furnace Co., U.S.A., recently arrived in this country, and his wide experience on all foundry melting problems is freely available through Messrs. Birmingham Electric Furnaces, Ltd.

Studies in the Recovery of Gold and Silver

Next in importance to the discovery of gold-bearing ores is the means adopted to extract the maximum quantity of their valuable contents, and this article summarises a recent report on some aspects of the recovery of gold and silver.

THE discovery of gold-bearing ores has been responsible, in a large measure, for the colonisation and development of continents; but next in importance to the discovery of ores bearing noble metals is the means adopted to extract their valuable contents. In some instances the contents are so small that much research has been necessary to render extraction profitable, while it has also been directed to the extraction of the maximum quantity whether the bearing properties of the ores are high or low. In this direction the United States Bureau of Mines has contributed to a large extent and further studies carried out under the direction of George L. Oldright, supervising engineer in charge of the rare and precious metals section, are contained in a recently-published progress report* on some aspects of the recovery of gold and silver. In this article extracts are given of some of the papers included in this report.

Amalgamation and Cyanidation.

A résumé of present methods for the recovery of gold by amalgamation and cyanidation is given by Edward S. Leaver, who states that the selection of a process for treating a gold ore is governed primarily by the characteristics of the ore under consideration. The form in which the gold occurs, its mode of association with other minerals, and the size and surface condition of the gold particles are important factors which influence materially the choice of procedure for recovering gold. A knowledge of these characteristics may be obtained by microscopic and chemical methods combined with experimental testing.

Cyanidation and amalgamation, either alone or in conjunction with flotation and gravity methods, are peculiarly adapted to the treatment of gold ores, especially those of relatively low grade. Gold alloys readily with mercury, provided both present clean surfaces. The presence of oils and grease, antimony and arsenic minerals, or soluble sulphides have a harmful effect. Very small, flaky particles of gold frequently are lost in amalgamation because of non-contact with the mercury. Fine gold in pyrite, or gold having rusty or contaminated surfaces, is often lost for the same reason. Grinding, or some form of abrasion, sometimes removes surface films of iron oxide or substances of a similar nature, and alkalis or other chemicals are used to remove grease.

Gold is readily soluble in cyanide solution, and this method of treatment is particularly effective in the recovery of gold from the tailings resulting from other types of concentration procedure. Cyanide solutions must contact the gold to ensure recovery, and the porosity of the ore treated and the fineness of grinding required are important governing factors. The use of lime in cyanidation is necessary to protect the cyanide, to precipitate undesirable substances, and to settle slimes.

Certain substances in ores are harmful in cyanidation; chief among them are those that combine with cyanide, forming cyanides, and carbon, which precipitates gold from solution. Arsenic and antimony are also harmful if present in sufficient quantity. These and other difficulties encountered in cyaniding certain ores often are overcome by roasting prior to leaching. Zinc dust is used almost universally for precipitating precious metals from cyanide solutions. The refining and melting of the product may be accomplished by oxidising the zinc before melting it in graphite pots with fluxes, although sulphuric acid is now used largely to remove the zinc before melting.

Straight cyanidation practice is being replaced by flotation as a major process, followed by cyanide leaching of the tailings, but amalgamation is still needed as a primary process for the recovery of coarse gold before either flotation or cyanidation.

Amalgamation during Fine Grinding.

Crushing gold ores to 65-mesh in the presence of mercury increases the gold recovery over that obtained by ordinary plate amalgamation, states E. S. Leaver and M. B. Royer. Too fine grinding with mercury causes excessive flouring and lower recovery of gold. A rotating cylinder amalgamator gave as good gold recoveries and less mercury loss than did crushing in the presence of mercury. The effect of various minerals on mercury losses in the processes studied was determined, and it is shown that carbon, arsenic, antimony, lead, zinc, and copper sulphides, alone or in the presence of iron sulphides, produce considerable mercury loss. Experiments on combined cyanidation, precipitation, and amalgamation were not successful, due to failure of the gold to amalgamate.

Flotation of Gold: Effect of Sodium Sulphide.

Sodium sulphide is an active depressant of clean metallic gold in flotation operations, according to E. S. Leaver and J. A. Woolf. Ores composed essentially of clean siliceous gangue are affected more adversely than those containing appreciable quantities of slime-forming minerals. A 30-minute conditioning period preceding flotation decreases the effect of the sodium sulphide on gold. Sodium sulphide acts as a depressant for gold-bearing pyrite and silver minerals. Therefore, the use of sodium sulphide in the flotation of oxidised copper and lead ores containing gold values should be deferred until after the precious metals have been floated.

Form and Occurrence of Gold in Pyrite from a Metallurgical Standpoint—Coated Gold.

This paper by R. E. Head is the second of a series describing results of microscopic studies made to determine the forms and occurrence of gold in pyrite. The stimulation of gold production due to existing economic conditions has resulted in classifying certain difficult treatable pyritic gold ores as refractory. Microscopic study of a number of these ores has developed interesting and valuable information concerning gold-bearing pyrite and the physical characteristics of the gold associated with it. An outstanding feature of much of the gold found in pyritic ores is its surface condition. Microscopic examination of gold particles isolated from refractory pyritic ores has established the fact that surface contaminations or coatings are of common occurrence.

These coatings may encase the gold particles entirely, or they may exist as films or tarnishes whose presence is rendered perceptible only by comparison with normal, clean gold. Particles having surface contaminations are more abundant in partly oxidised pyrite. The fact that coated gold particles have been identified constantly in the flotation of cyanide and amalgamation tailings has been construed to indicate that failure to recover them was due primarily to the contaminated condition of the gold surfaces.

Different types of surface contaminations exist, since some coated gold will not cyanide, but can be floated, and other types can be cyanided, but will not float. Iron usually is present in the surface film, and in some cases contaminated gold particles are weakly magnetic, presumably because

* U.S. Bureau of Mines Report of Investigations, 3275.

of the iron. Micro-chemical tests have confirmed the existence of iron in coatings on gold, but preliminary spectrographic study of contaminated gold particles indicates the existence of silver, lead, manganese, aluminium and titanium. It is not known whether these elements are confined to the surface coatings or whether they are alloyed with the gold.

The surfaces of contaminated gold particles were blackened by a one per cent. solution of sodium sulphide, applied as a micro-chemical reagent, but results of flotation tests in which sodium sulphide was used indicate that extended conditioning is necessary when sodium sulphide is introduced into the ore pulp in small quantities. Sodium sulphide is a depressant of clean gold, and any beneficial effects derived from its use would be limited to gold articles having contaminated surfaces.

Flotability of Lead and Silver Jarosites.

Data resulting from an investigation of jarosite minerals, are presented by R. E. Head and F. E. Thackwell. Plumbojarosite and argentojarosite are of more common occurrence than is generally realised. They occur in grains of very small size, and crushing reduces them to slime similar to that of iron oxide, which they resemble. Various flotation procedures were tried, using 0.5 lb. of terpineol per ton as a standard amount of frothing agent. Sulphidising followed by treatment with copper or iron salts proved unsuccessful. Sulphuretted pine oil is an efficient collector for plumbojarosite. Plumbojarosite is floated readily by both saturated and unsaturated fatty acids. Increasing the temperature of the pulp increases the recovery with high-melting-point fatty acids.

Reviews of Current Literature

Light Alloy Handbooks

Two very valuable handbooks on light alloys have recently been published which are of an outstanding character. One is issued by Northern Aluminium Co., Ltd., and the other by The Birmingham Aluminium Castings (1903) Co., Ltd.; both are issued in loose-leaf form in order that revisions and additions, which will be issued periodically, can be easily incorporated. The former is 4to in size, while the latter is 8vo.

Noral Handbook

This handbook, issued by Northern Aluminium Co., Ltd., Bush House, Aldwych, London, W.C. 2, is presented in three sections; sections A and B being bound together, while section C is bound separately. It is designed to give concise information regarding the products of the publishers, and includes details of the various alloys available, together with physical properties, manufacturing limits, tolerances and specifications.

Section A is concerned primarily with general information, which covers a very wide range of data on aluminium alloys. Section B is concerned more especially with sheet and plate; in this section a short but useful description of the majority of the principal aluminium alloys and their uses is given, with data sheets of value to the user of plate and sheet aluminium alloys and "Alclad." Section C, which deals with extruded sections, is a valuable medium of information to the designer of all forms of constructions in which the light alloys are being increasingly used. This section will assist materially in the selection of suitable sections, particularly as the dies available are shown either in tabular form or illustrated to scale.

This handbook is an excellent publication and one which can be used with profit by engineers and designers. It embraces much information that the designer and engineer using aluminium alloys must have, and since the information is concise and is supported with appropriate data, there is no wasted time in applying it.

Birmal Technical Data Sheets

These technical data sheets, which are issued by The Birmingham Aluminium Castings (1903) Co., Ltd., Birmid Works, Smethwick, near Birmingham, have been compiled and published to provide users with comprehensive and authoritative information concerning the physical and mechanical properties, corrosion-resisting qualities and applications of aluminium base and other alloys, suitable for sand, gravity and pressure die-casting purposes. Other sheets deal especially with corrosion, protection against corrosion, and machining with particular reference to aluminium alloys. The book includes very comprehensive technical information relating to the composition and physical and mechanical properties of no fewer than 17 distinct light alloys of aluminium, 4 alloys of magnesium, these latter all being known under the registered name "Elektron," and one zinc alloy.

The compilation of this book represents the work of a Committee of the Staff of the publishing company spread over a considerable period, and the latest issues of official specifications by the British Standards Institute and by the Air Ministry have been taken into account. The book is admirably prepared, of convenient size, and will be in great demand by users and prospective users of light alloys because of the valuable information incorporated from a variety of sources.

Cast Metals Handbook

This handbook deals exclusively with the properties and applications of cast materials. It presents modern information on castings and corrects much erroneous and obsolete data on which engineers base their calculations.

The information is conveniently arranged in eight sections: recommendations to designers of castings, recommendations to buyers of castings, one section each on the properties and applications of cast iron, malleable iron, steel and non-ferrous cast metals, a cross-index of the material contained in the volume and an advertising section.

The first section deals with the design of pattern equipment from the point of view of what the engineer should take into consideration when designing equipment in which castings are used. This division also contains some pointers in design which should be of material aid to engineers and designers in securing better castings. The data contained in the second section deals with the information that should be given the producer by the buyer so that the producer can correctly estimate the cost of the job. Complete information eventually reflects to the benefit of the purchaser both in cost and quality of the castings. The next four sections deal with the properties and applications of cast iron, malleable iron, steel and non-ferrous metals and alloys. Included in the data in these sections are physical properties, physical constants, properties at room, elevated and sub-normal temperatures, ranges of chemical composition, specifications, metallurgy, testing methods, and much other data. Considerable information also is given on cast materials for heat, corrosion and wear resistance, including such data as room and high-temperature physical properties, chemical compositions, service temperatures and the resistance of various alloyed materials to corrosive media. Applications of the various plain and alloyed materials also is given.

The book is particularly useful to engineers, designers and users of castings, and to foundrymen. It is well produced, and the text matter conveniently arranged and adequately indexed.

Published by the American Foundrymen's Association, 222, West Adams Street, Chicago, Ill., U.S.A. Price $4.00.

INSTITUTE OF METALS

Annual Autumn Meeting at Newcastle

THE proceedings at the Annual Meeting of the Institute of Metals began on Monday evening, September 9, under the chairmanship of Dr. Harold Moore, C.B.E., who is now serving his second year as President of the Institute, when the Fourteenth Annual Lecture was delivered by Dr. H. W. Brownsdon, M.Sc., in the King's Hall, Armstrong College, Newcastle-on-Tyne. During the following morning a civic welcome was extended to the Institute by Dr. J. W. Leech, M.P., acting on behalf of the Lord Mayor of Newcastle-on-Tyne, supported by the Sheriff, in the King's Hall, Armstrong College; afterwards, a general meeting of members was held in the new Mining Lecture Theatre, Armstrong College, for the presentation and discussion of papers. The next morning was also devoted to a technical session, while during the afternoon of September 10 and 11 the members visited several works in the vicinity; these included Sir W. G. Armstrong Whitworth and Co., Ltd., the Dunston Power Station of the North-Eastern Electric Supply, Co., Ltd., North-Eastern Marine Engineering Co., Ltd., C. A. Parsons and Co., Ltd., A. Reyrolle and Co., Ltd., and the Wallsend Shipyard of Swan, Hunter and Wigham Richardson, Ltd. A special programme was arranged for the ladies of members attending the meeting, and the final day, September 12, was devoted to a whole day motor excursion, during which a short visit was paid to the famous Chester's Museum at Chollerford, the Roman Fort at Borcovicus, and adjacent parts of the Wall were inspected.

In addition to the Annual Lecture, sixteen technical papers were presented at this meeting, embracing a wide range of non-ferrous studies, brief abstracts of which are given in the following notes.

Observations of the Porosity and Segregation of Two Bronze Ingots.

The processes leading to the formation of cavities in an ingot were discussed in a previous paper,* and reasons were given for considering the phenomenon of inverse segregation to be largely the result of the same process. The present work, by Dr. N. P. Allen, M.Met., and Mr. S. M. Puddephat, B.Sc., was undertaken in order to study further the distribution of porosity in ingots, and to obtain more evidence on the relationship between porosity and segregation. As a result of this investigation the authors found that the distribution of cavities and copper in chill-cast 10% tin-bronze ingots is determined by the flow of heat away from the casting in such a way that the parts of the ingot which solidify last are more porous and richest in copper. Both distributions are explicable on the assumption that during solidification a liquid rich in tin travels towards the outside of the ingot. In this case the authors conclude that contraction during solidification was the principal cause of the movement.

Metal Losses in Melting Brass and other Copper Alloys.

Although quality is one of the primary objectives in metal melting, other factors have an important influence on economical production, not the least of which is the loss which, in varying degrees, occurs in melting. Many factors influence the magnitude of the loss, such as method of melting, type of furnace used, temperature of heating, precautions for the prevention of oxidation, methods of recovery, etc.; the compositions of alloys also influence the degree of loss, some metals being more readily oxidisable than others. The subject is a wide one, but in the present paper Dr. Maurice Cook, M.Sc., deals only with a few typical non-ferrous metals and alloys, and, for the most part, with only two forms of melting.

The author has made a study of the metal losses which occur when such alloys as gilding metals, brasses, and cupro-nickel are melted in crucibles in coke-fired pit furnaces, and for this purpose figures have been obtained both from carefully controlled trials and from production runs, involving the melting of considerable quantities of material under different conditions.

Observations have also been made on the metal losses occurring in melting brasses of different compositions under various conditions of fluxing in Ajax-Wyatt induction furnaces, and large-scale trials, covering considerable periods and involving large tonnages of metal, have been made. The loss is largely due to oxidation and the results of various methods of reducing the loss, such as varying the nature and amount of flux, the use of charcoal, coke, anthracite, and coal-gas, which have been tried are discussed.

The Properties of Some Special Bronzes.

The experiments described in this paper by Professor D. Hanson and Mr. M. A. Wheeler constitute a survey of the effects of aluminium, manganese, aluminium plus manganese, silicon and iron on the hot- and cold-working properties of the bronzes, and on the mechanical properties of the rolled products. The authors also make some observations on the microstructures of the various alloys used. The results of these experiments are briefly summarised in the following:—

Aluminium.—Within the range of compositions investigated, alloys consisting of one solid solution work readily—hot or cold. Alloys possessing a duplex structure can be worked with much greater difficulty, and are specially difficult in hot-working. The range of compositions in which easy working properties can be obtained can be extended by annealing duplex alloys, to give a homogeneous structure. Annealed alloys possess very good ductility; the maximum tensile strength attained in annealed alloys was 30 tons/sq. in. in an alloy containing 4% aluminium and 5% tin. Alloys containing 2% or more aluminium are fairly resistant to oxidation at high temperatures, particularly if the cast surface is not damaged. Polished alloys have a pleasing appearance, and are fairly resistant to tarnishing in the air. The scale formed when the alloys are heated is very difficult to remove, either mechanically or by pickling processes.

Manganese.—Manganese has a relatively small influence on the working properties of a 5% tin bronze. As much as 6% of manganese must be added before an appreciable embrittling effect is apparent. Alloys within the range of composition investigated can be worked hot or cold. Manganese increases the softening temperature of the tin bronzes.

Aluminium and Manganese.—Copper-tin bronzes, containing aluminium and manganese, within the range investigated, are difficult to cold-work without annealing if the aluminium content exceeds about 0·25%. With aluminium contents up to about 4% they may be cold-worked if they are previously rendered homogeneous in structure by annealing. Aluminium increases the tensile strength of manganese-tin bronzes without appreciably reducing the ductility.

Iron.—Iron, in the form of American-washed iron, alloys readily with copper, and 4% of iron can be incorporated without difficulty. No trouble was experienced in obtaining good castings. Iron-tin-copper alloys containing 5% of

* N. P. Allen, *J. Inst. Metals*, 1933, 52, 193.

tin and up to 4% of iron can be rolled, and the ductility decreases only slightly even when 3% or 4% of iron is present. Iron up to 1·5% has little effect on the tensile properties of a 5% tin bronze, but 2% or more of iron increases the tensile strength at the expense of the ductility. The iron is distributed uniformly throughout the solid alloy in the form of small particles, the structures being very similar to those of iron-copper alloys containing no tin. 4% of iron greatly refines the cast structure of a 5% tin bronze.

Silicon.—Silicon has a marked effect on the cold-working properties of a 5% tin bronze. An alloy containing 3% of silicon can be cold-worked only with great difficulty in the "as-cast" condition: after annealing at 800° C. for 4 hours the cold-working properties are slightly increased. The addition of 4% of silicon to a 5% tin bronze renders the material unworkable both hot and cold. The addition of silicon greatly increases the strength of a tin bronze.

An X-ray Investigation of Certain Copper-Tin Alloys.

The structures of all the main phases in the copper-tin system have already been investigated by different workers with the aid of X-ray crystal analysis.

In the present investigation, by Professor E. A. Owen and Dr. John Iball, attention is directed mainly to the α-phase boundary, although several alloys in adjacent phases were examined during the course of the work. The results indicate that certain modifications are necessary in this section of the equilibrium diagram. Further investigation is required, however, to establish these changes, and for this purpose it is desirable to examine the alloys at high temperatures. The investigation is progressing along these lines, but it was considered that the data already obtained would be of interest as they support the conclusions of some of the previous workers and extend those of others. This paper is to be regarded, however, as a preliminary account of a more extensive survey on this system of alloys which is in progress at the authors' laboratory.

In this investigation the α-phase boundary of the copper-tin alloys has been determined by X-ray analysis between 750° and 300° C. Its position between 750° and 500°C. is moved in the direction of slightly higher tin content, but between 500° and 300° C. in the direction of lower tin content than that of the boundary as previously determined. The maximum solubility of tin in copper occurs at about 520° C., the temperature corresponding to the (β) to ($\alpha + \gamma$) transformation. The parameter of the γ-phase is found to lie between 17·917 and 17·924 A at 480° C., but the measurements are not considered sufficiently extensive to decide whether there exists a definite region of solubility for this phase. The ε-phase is a solid solution, the range of which does not exceed 1·5% copper by weight at 380° C. The atomic volume of the copper-saturated ε-phase at this temperature is found to be 14·124 A^3, and that of the tin-saturated phase 14·177 A^3. The results so far obtained suggest that a transformation of (γ) into ($\alpha + \epsilon$) occurs at a temperature slightly higher than 300° C., and that the copper-saturated boundary of the ε-phase is not exactly vertical between 380° and 300° C.

The Inter-Relation of Age-Hardening and Creep Performance.

PART I.—THE AGE HARDENING OF NICKEL-SILICON-COPPER ALLOYS.

This paper by Dr. C. H. M. Jenkins and Mr. E. H. Bicknall, M.Sc., describes work carried out in the Metallurgy Department of the National Physical Laboratory for the Committee on Materials for High-temperature Service of the Department of Scientific and Industrial Research. It gives a report of an investigation on the age-hardening of nickel-silicon-copper alloys containing 3% and 5% nickel + silicon in the atomic ration 2 Ni : 1 Si. The work, which was carried out as a preliminary to the study of the inter-relation of the age-hardening of this material and its creep performance, has provided sufficient information to serve as a basis for the creep test programme, and to assist in the interpretation of the creep results.

The alloy containing 3% nickel + silicon when quenched from 900° C. undergoes age-hardening at temperatures of 300°—750° C. The maximum hardness is attained progressively more rapidly the higher the age temperature being reached, for example, in more than 64 days at 400° C., and in less than 1 minute at 700° C. In general, a linear relationship appears to apply between the logarithm of the time and the reciprocal of the absolute temperature of attainment of maximum hardness. The maximum hardness is greater the lower the ageing temperature. The attainment of maximum hardness is generally followed by softening.

Microscopical and chemical evidence of the progress of ageing has been obtained, but X-ray study has not been of great assistance in this instance.

In an Appendix the authors give consideration to points relating to the age-hardening of nickel-silicon-copper alloys and their comparison with information in the literature relating to other age-hardenable alloys. Particular attention is directed to the importance of the relationship between temperature and time of attainment of maximum hardness, which is shown to be of general application. A similar relationship applies to the attainment of maximum resistivity during ageing. These relationships are regarded as confirming the commonly accepted theory of age-hardening.

An Investigation of the Nature of Creep under Stresses produced by Pure Flexure.

Many structural components are subject to complex systems of stress which, at high temperatures, give rise to creep. Among the more simple cases of complex stress is that which arises in a part subject to flexural stresses. Considerable experimental difficulties are associated with an investigation of the creep of a metal at high temperatures under flexural stresses, but advantage may be taken of the fact that a soft metal, such as lead, at air temperature simulates the behaviour of steel at high temperature. In the work described in this paper by Messrs. H. J. Tapsell and A. E. Johnson, a pure lead beam was subjected to flexural stresses at a temperature of 21·5° C.

Apparatus was constructed by which a beam of lead was subjected to uniform bending moment, and measurements of the creep of the beam were recorded. The whole equipment was housed in a chamber maintained at constant temperature. Tensile creep tests on the material of the beam were also carried out at constant temperature, in order to provide stress-strain data for the calculation of the stresses in the beam.

The investigation led to the following conclusions: (1) in the case of a lead beam creeping under stresses produced by pure flexure, plane sections continue to remain plane; (2) the redistribution of stress arising from creep is complete within one-fifth of an hour after application of a bending moment, and the stresses continue unaltered with time; (3) the behaviour of the beam under flexure may be fairly computed solely from the relations between tensile stress and rate of strain corresponding to any period of tensile creep testing on the material of the beam.

Note on the Effect of Interrupted Straining on the Elongation of Lead.

It has been found that by interrupting a tensile test on commercially pure lead at intervals, during which the specimen is allowed to rest for a short time free from stress, abnormally high values of elongation are produced. These may be as much as five times those obtained in a normal tensile test. The influence on the elongation of the duration of the rest period, the rate of straining, the amount of elongation between successive rest periods, and the grain-size have been studied by tests on extruded cable-sheath samples, and the results given in this paper by Mr. J. C.

Chaston, B.Sc. Abnormal elongations are not produced by interrupted straining on "hardened" lead alloys at room temperature, but it is suggested that such effects may be obtained in these and any other metals and alloys if they are tested above their recrystallisation temperatures. The observations recorded may thus have a bearing in connection with high-temperature metallurgical research.

Corrosion below Discontinuous Oxide Coatings, with Special Reference to Magnesium.

The value of any protective treatment depends not so much on its power to prevent attack where the treatment has been perfect, as on the happenings at points where the treatment has been originally insufficient or subsequently damaged. Considerable work has been done in the study of metallic coats and paint coats, but it is important to distinguished two classes of protective treatment: (*a*) a dangerous class, where incomplete treatment causes intensification of attack and brings about perforation sooner than it would occur on untreated metal; and (*b*) a safe class, where incomplete treatment, whilst not preventing attack, at least renders the time needed for perforation longer than that of unprotected metal. For many types of protective treatment much of the information necessary to assign processes to one or other class is available; but in regard to protection by oxide coats, there appears to be no record as to whether or not an insufficient coating can cause intensification of attack. Yet oxide coats are to-day largely used in protection, especially on magnesium and aluminium. In connection with oxide coats it is reasonable to hope that, in some at least of the processes available or capable of being worked out, "incomplete treatment" would cause no shortening of the perforation time. The experiments described in this paper by Mr. K. G. Lewis, M.Sc., and Dr. U. R. Evans were designed to examine this matter in respect to magnesium.

Using a new "self-circulating" apparatus, the authors have obtained time-corrosion curves for: (1) untreated magnesium in sodium chloride, (*a*) after different abrasions, and (*b*) in baths of different concentrations; (2) magnesium treated in three different baths, two used previously by Sutton and Le Brocq, and one a new bath containing zinc sulphate and ammonium nitrate, after different periods of treatment. In addition, times of penetration have been determined after different periods of treatment in all three baths.

The results suggest that oxide coats on magnesium may, for the experimental conditions surveyed, be assigned provisionally to the "safe" class. Reference is made to some intermittent spray tests, commenced on magnesium treated by different processes, including Bengough and Whitby's selenium process.

The Protection of Magnesium Alloys Against Corrosion.

In a previous paper* Mr. H. Sutton, M.Sc., and Mr. L. F. Le Brocq, B.Sc., described experiments which showed that substantial protection of magnesium-rich alloys could be obtained by surface films produced by immersion of the cleaned pieces of the alloy for about 6 hours in a bath containing potassium dichromate, 1·5%; potash alum, 1%; and caustic soda, 0·5%, heated to 95° C. For some purposes this treatment has been found to be inconvenient on account of the lengthy period required for the treatment. Experiments have now been carried out with the object of evolving a short-period immersion treatment, which the same authors describe in the present paper, and it has been found that treatment for 45 minutes in a bath containing potassium dichromate, weight, 0·75%; ammonium dichromate, weight, 0·65%; ammonium sulphate, weight, 3·0%; ammonia (0·880), by volume, 0·33%, and used at boiling point gives a degree of protection very little inferior to that afforded by the bath previously mentioned. The bath was found to be capable of repeated use without loss of efficiency. During use of the bath the *ph* value remains nearly constant at about 6·5, and the reason for this appears to be that as magnesium is dissolved from the work under treatment, ammonia is liberated from the ammonium salts present and escapes from the boiling solution.

The protective value of the 6-hour and short-time chromate treatments, with and without supplementary coatings of varnishes and enamels, has been investigated with reference to typical alloys. Intermittent sea-water spray laboratory tests and beach exposure tests were carried out, and the corrosion which occurred was observed by loss of weight and change in mechanical properties. Experiments were carried out on the influence of cleaning treatments employed before chromate treatment.

* H. Sutton and L. F. Le Brocq, *J. Inst. Metals*, 1931, *46*, 43-72.

Alloys of Magnesium.

Part III.—Constitution of the Magnesium-rich Alloys containing Aluminium and Cadmium.

This paper, by Dr. J. L. Haughton and Mr. R. J. M. Payne, B.Sc., forms Part III of the investigation of the constitution and mechanical properties of the alloys of magnesium which is being conducted at the National Physical Laboratory under the supervision of Dr. C. H. Desch, F.R.S., and at the instigation of the Alloys Sub-Committee of the Aeronautical Research Committee.

This particular research was instituted to provide a theoretical basis for the work on the mechanical properties of magnesium containing additions of cadmium (the presence of which improves the ductility of the alloys) and of some other metal (in this case aluminium) to provide strength and hardness. The work on the mechanical properties has been directed to strike a balance between the opposing effects of cadmium and aluminium, and to obtain an alloy which possesses in fair measure both ductility and strength. The research was also intended to furnish data for investigation of the possibility of improving the alloys by precipitation-hardening. The range of alloys examined was restricted to those containing not more than 20% of any one added element.

It is shown that the addition of cadmium to magnesium-aluminium alloys depresses the liquidus slightly, 20% cadmium lowering the liquidus temperature of an 80% magnesium 20% aluminium alloy by about 50° C., but has practically no effect at the temperature of the aluminium-magnesium eutectic. It also reduces the solubility of aluminium in magnesium to a small extent. No new phases are found up to 20% of each added element, but attention is directed to an abnormal form of precipitation which was found in some of the alloys.

X-ray Study of Copper-Silver Alloys.

In this paper, by Professor E. A. Owen and Dr. Joseph Rogers, an investigation is described by which the phase boundaries in the thermal diagram of copper-silver alloys have been determined by the X-ray method. A general survey showed that the phase fields were the same as those in the generally accepted diagram of the system. More detailed investigation with the precision X-ray camera yielded accurate values of the solubilities of copper and silver in each other. These values are compared with the more recently determined values, with which they are found to be in fair agreement. The solubilities of copper in silver and of silver in copper at 778° C. are found, respectively, to be 8·5% and 8·4%. These solubilities decrease to 1·8% and 1·4% at 500° C., and to 0·2% and 0·1% at 200° C. The extrapolated experimental curves indicate that the one metal is almost insoluble in the other at room temperature.

The Determination of Certain Phase Boundaries in the Silver-Zinc Thermal Diagram by X-ray Analysis.

As a result of this investigation by Professor E. A. Owen and Mr. I. G. Edmunds, M.Sc., the phase boundaries in the region extending from the γ- to the ϵ-phase of the

silver-zinc thermal diagram have been determined by X-ray analysis. The crystal parameters are accurate in general to 1 part in 5,000; in some of the determinations the accuracy is much higher than this. The results confirm the existence of the phase fields contained in the generally accepted diagram of the system, but they indicate that the positions of the boundaries need readjustment. The $(\gamma) - (\gamma + \delta)$ boundary requires adjustment in the direction of lower silver content, by about 0·5% silver by weight at the lower temperatures, and by a progressively greater amount in the opposite direction as the temperature is increased. The $(\gamma + \delta) - (\delta)$ boundary needs to be displaced towards the silver end of the diagram through about 4% in composition, thus reducing the width of the $(\gamma + \delta)$ region to about half its former value. The $(\delta) - (\delta + \epsilon)$ and $(\delta) - (\delta + \eta)$ boundaries are more nearly parallel to the temperature axis than those shown in the thermal diagram published in the International Critical Tables. At the higher temperatures the $(\delta) - (\delta + \eta)$ boundary moves towards the silver end through about 4% in composition. The $(\delta + \epsilon) - (\epsilon)$ boundary is parallel to that in the accepted diagram, but needs an adjustment of about 1% towards the silver end of the diagram.

Note on the Failure of a Gold Fuse in Contact with Nickel-Chromium Alloy.

In this paper Mr. M. C. Caplan, B.Sc., describes the failure of a gold safety fuse to operate at the correct temperature. This failure was found to be due to diffusion taking place between the gold link and the nickel-chromium connections at temperatures of 950°—1,000° C. An alloy of lower melting point is formed which offers little resistance to oxidation, and, finally, the gold link becomes disintegrated and converted into a cindery residue.

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(*Continued from page* 144.)

relatively simple case of unalloyed carbon steels. The authors do not claim, however, that this morphological study is complete; it is certain that, even in the compass of the first part of this paper, other types of inclusions may be met with.

The paper does enable certain general observations to be made regarding the crystallography or appearance of the inclusions and their relation to the composition and method of manufacture of the metal, besides which it throws a certain amount of light on certain features of the manufacturing process, especially as regards the conditions under which the inclusions are formed. By attentively studying the inclusions in the metal, the authors claim that the skilled and conscientious observer is able to reconstruct certain "stages" or retrace certain operations performed during the manufacture of the metal, and which of course, elude all other methods of investigation. These operations leave indelible traces on the nature or appearance of the inclusion. The greatest prudence must, however, be exercised when pronouncing judgment on these inclusions, as the large number of different inclusions met with in steel makes it difficult to arrive at a true assessment. This also demonstrates the irregular nature of the action of the additions, which cause localised increases of concentration and also of temperature, the latter being revealed by the melting of certain refractory inclusions.

The inclusions are much more difficult to identify in forged metal, in which they lose their typical appearance. On the other hand, this examination gives information as to the plasticity and hot-shortness of the inclusions. This research, the authors state, will be completed by a second portion dealing with the morphology of the inclusions in the iron alloys containing special elements, and chromium in particular.

Magnuminium Sand and Die-casting Alloys.

Magnesium and its alloys are being increasingly used when it is desired to obtain maximum strength with minimum weight. The alloys of this metal are used in both the cast and wrought states, and it is noteworthy that for sand and die-castings two "Magnuminium" magnesium base alloys are available, both having excellent physical and mechanical qualities. Of these "Magnuminium" 177 to D.T.D. 59A, a general sand and die-casting alloy, has the highest mechanical properties, while "Magnuminium" 220 to D.T.D. 136A, with a slightly lower tensile strength, has been developed primarily for use in castings subject to high-fluid pressures where optimum homogeneity is of paramount importance.

Details of the mechanical and physical properties of these alloys are given in the accompanying tables:—

	Magnuminium 177 to D.T.D.59A.	Magnuminium 220 to D.T.D.136A.
Specific Gravity	1·80	1·81
Weight lbs/Cub.Ft.	0·065	0·066
Coefficient of Thermal Expansion per °C.	0·000025	0·000025
Thermal Conductivity C.G.S. Units	0·18	0·17
Melting Point	610° C.	590° C.
Modulus of Elasticity lbs/Sq. in.	$6·5 \times 10^6$	$6·5 \times 10^6$

TENSILE TESTS.

MAGNUMINIUM 177.

Condition.	0·1% Proof Stress Tons per sq. in.	Max. Stress Tons per sq. in.	Elongation % on 2 in G.L.	Brinell Hardness Number
Sand Cast—B.S.I. Mould	4·0—5·0	9·0—11·5	2—8	45—55
Die Cast—A.I.D Mould	5·0—6·5	14·0—16·5	8—15	50—60

MAGNUMINUM 220.

Condition.	Proof Stress Tons per sq. in.	Max. Stress Tons per sq. in.	Elongation % on 2 in G.L.	0·1% Brinell Hardness Number
Sand Cast—B.S.I. Mould	4·5—5·5	8·0—11·0	2.4	50—60
Die Cast—A.I.D. Mould	5·5—6·5	11·0—14·0	2—5	50—60

NOTE.—All Test Bars cast to 1 in. dia. and machined to 0·654 in. dia.

Both these alloys have excellent machining characteristics permitting smoother, more even finish to be obtained at maximum cutting and feeding speeds than from the majority of other commercial metals. They are manufactured by Magnesium Castings and Products, Ltd., Buckingham Avenue, Slough.

The Peace-time Development of Alloys

The charge is sometimes made that the development of alloys is primarily associated with the manufacture of war materials, and while sane people are not likely to be influenced by such an absurd charge, a recent letter by Mr. R. C. Stanley, to the shareholders of the International Nickel Company of Canada, Ltd., draws attention to the extraordinary development of the peace-time uses of nickel which have taken place during the last decade.

The Alloy Age had its inception in the World War, and thus nickel, as a useful alloying element, became associated in the public mind with munitions. With the passing of years, this Alloy Age has become linked with the progress which is being made in transportation, communication and industry at large, and nickel continues in its rôle as one of the most useful of the alloying elements. The result is that more nickel is currently going into the numerous fields of peace-time activities than ever went into the world's battlefields.

Recent Developments in Materials, Tools and Equipment

AN ELECTRO-MAGNETIC FATIGUE TESTER

A NEW type of fatigue tester that provides a life test on sample steel bars, and can also be adapted for testing non-magnetic metals has recently been developed by Salford Electrical Instruments Ltd., an associated company of the G.E.C. In this apparatus the sample bar or rod is supported at its two nodes and vibrated electro-magnetically so that it resonates, a method that allows a very great number of cycles of stress to be applied to the bar in a relatively short time. By measuring the deflection of the bar at an antinode, the actual stress applied can be calculated using the modulus of elasticity E, which can be determined from the frequency of the vibrating bar; the number of cycles applied to the test bar before failure can be indicated by a recorder. It may also be noted that a means of tripping the whole gear is provided to operate on the occurrence of a crack in the specimen. More than one bar may be vibrated at once by providing several units, and the different failure times caused by varying the stress on each can all be indicated on the chart of one recorder.

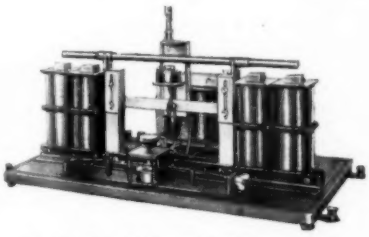


Fig. 1. Bar holder and electro-magnets.

Fig. 2. Power supply unit.

The complete apparatus comprises three parts:—(1) the bar-holder and electro-magnets, (2) the power supply unit, and (3) the recorder (not essential). The first two items are illustrated in Figs. 1 and 2, respectively.

The bar (of whatever material) is supported in vee notches, and is rubber covered at these points to obviate chattering due to the imperfection of the mechanical contact. For non-ferrous metals it is necessary to provide steel sleeves over the test bar in the region of the exciting magnets, and a small steel clip in the centre for the pick-up.

The electrical circuit uses an a.c. supply, which is transformed for filament heating and rectified for supplying the gas-filled relay anode and the d.c. polarising magnets. The electro-magnets for vibrating the bar consist of two pairs of coils on two iron circuits. One pair of these coils is excited by d.c., and provides a constant polarising field. The other pair is excited by alternating current from the gas-filled relay circuit, in which the relay with its condensers and inductances forms a variable frequency oscillator. This oscillator can be adjusted so that the electrical frequency corresponds to the mechanical natural frequency of the bar. When this occurs the bar resonates with a relatively large amplitude, and is held in synchronism (vibrating at the same amplitude even when the applied voltage varies or the circuit constants alter slightly) by means of a pick-up under the centre of the bar, which is connected in the grid circuit of the relay.

In order to trip the circuit on a crack occurring an auxiliary vibrator is provided. This vibrator comprises a length of steel spring, the tension of which can be adjusted to vary the natural frequency, and is excited from the same circuit as the main a.c. coils; after tuning the main circuit the auxiliary vibrator is tuned by varying the tension, and then detuned slightly by a half-turn backwards of the tension-screw, the natural frequency being thereby lowered so that no appreciable vibration occurs. On a crack appearing in the specimen, the natural frequency is reduced, and the auxiliary vibrator comes into action, vibrating with an amplitude sufficient to touch a fixed contact; this closes a local circuit and short-circuits part of the resistance in the grid-filament circuit, causing the gas-filled relay to take an increased anode current, which trips a small circuit breaker. The unit is thus shut down, and the corresponding pen of the recorder is lifted up so that the record indicates the point at which the particular bar has failed.

The recording drum is driven by a synchronous motor, supplied from the oscillator that vibrates the lowest-stressed bar. As the time of operation or the number of cycles endured varies over wide limits, a logarithmic scale of cycles is necessary in order to cover the range, which for steel bars may be taken as about 10^4 to 10^8 cycles.

The standard G.E.C. fatigue tester is designed for half-inch round steel bars of 18in. in length, for which the natural frequency is between 250 and 300 cycles per second; modifications of distance between centres, etc., are required for other dimensions The apparatus may also be adapted to deal with non-uniform loads and the application of a fixed bending load or torsion at the same time as the vibratory stress.

Bal-Nel Alloy

A new alloy known as Bal-Nel alloy has been developed which in appearance resembles pure nickel, has a silvery lustre and takes a high polish similar to silver. It is claimed to be as strong, tough and ductile as steel, and under corroding influences is very much superior to copper, gunmetal and bronze. It is stated to be composed of copper, nickel and other metals and is made in five grades to meet the requirements of various industries and trades.

Corrosion tests recently carried out at the Royal Technical College, Glasgow, show that this alloy is comparable with the highest class of alloys known to be able to resist corrosion. With many corrosive media the corrosive action is so small as to be negligible. Because of its resistance to corrosion, this alloy is claimed to be admirably suited for handling corrosive liquids and waters as in chemical works, mining plants, laundry plants, dyeing plants, pickling vats, etc.

In addition to high resistance to corrosion, it possesses high strength, results corresponding to high-quality steel being regularly obtained, and this strength is retained at relatively high temperatures. Laboratory tests are stated to have shown that softening of the alloy does not commence until a temperature of 400° C. is exceeded, and that in order to reduce the hardness below 100 Brinell, a mean temperature of at least 850° C. is necessary.

The important characteristics of this alloy for which special claims are made are: 1, it provides a complete resistance to corrosive action by sea water, changing atmospheric conditions, alkalis and most acids; 2, it is extremely tough combined with high-tensile strength, both in cast and rolled material; 3, it retains a high proportion of strength when subjected to elevated temperatures; and 4, it is readily cast, machined, forged, rolled, welded, and drawn into tubes, wires, etc., and easily made into the various standard commercial forms.

The Influence of Nozzle Refractories on Teeming Speeds of Ingots

By A. JACKSON.

It is sometimes assumed that the work of the steelmaker is finished when the ladle is filled from the furnace and the steel is ready for teeming, but it is very easy to spoil good steel by faulty or careless handling in subsequent operations. One of the most important factors which influence the quality of the finished product is that of teeming the steel from the ladle into the ingot mould, and in this article the difficulties are discussed with special reference to nozzle refractories.

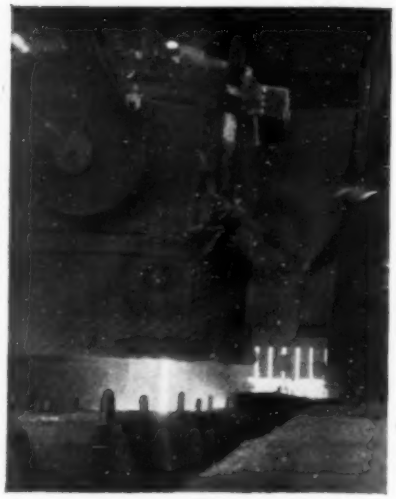


Fig. 1. Teeming ingots.

STEELMAKING is as much an art as a science, and however much care may be exercised in the furnace and, subsequently, in the ladle to ensure the high quality of the required grade of steel, many of the steelmaker's troubles arise through difficulties encountered during the operations that follow, in which the fluid steel is converted into what the steelmaker regards as his finished product. Of the difficulties experienced, not the least important is concerned with the teeming of the metal from the ladle into the ingot mould. As is generally known, the metal passes through a nozzle of refractory material, and the flow is controllable by means of a refractory stopper, bedding on to the face of the nozzle when required, and so shutting off the metal stream.

Teeming the heat of steel is second in importance only to the making of the steel. Here many defects which occur in the product may be introduced. These include cracking; shelling, due to splashing when teeming; blistering; lapping; and hanging crusts. Some of these defects in the finished or semi-finished material may, of course, also arise from other causes, but teeming has a very large effect; a brief reference to these defects in relation to teeming therefore will be of interest.

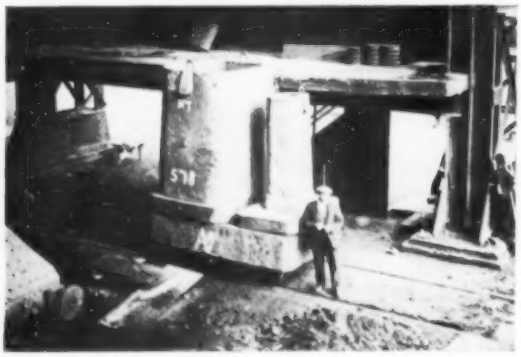


Fig. 2. Showing 2-ton and 25-ton moulds in casting position.

Cracking.—In ingots, slabs, and blooms, in general, cracking increases in quantity with increased speed of teeming, other conditions being constant. In the case of ingots, rapid teeming will often cause vertical corner cracks, and very rapid teeming may even give vertical cracks up the centre of the ingot face. Too rapid teeming again increases the tendency of ingots to crack during rolling into slabs or blooms, though this tendency may be neutralised by careful rolling during the first few passes.

Shelling.—This is caused mainly by splashing steel on to the mould wall during teeming. A thin crust rapidly chills and becomes oxidised; in consequence it never unites with the main body of material during subsequent working, thus it is necessary to cut out the shelly portions as scrap.

This defect may be caused by careless teeming or by an unsatisfactory nozzle. In the latter case part of the stream may be deflected from the main body and impinge upon the mould wall, giving shelly slabs and blooms. If this shell on the mould wall looses contact and becomes surrounded by molten steel, the surface of the ingot, when stripped, will appear good, but almost invariably a blister will occur during the hot-rolling of a plate or sheet made from this ingot. A hard-burned, highly vitrified nozzle will often crack during teeming and give rise to the above defects. Pots are also found in which the clay is apparently not homogeneous. These wear unevenly, and again give rise to these defects.

Lapping.—When the teeming is too slow lapping is shown on the ingot surface; while in the case of "hanging crusts" the teeming is so slow that the upper surface partially solidifies, and it becomes covered by the rising steel. The solid crust remains suspended within the ingot, and will almost certainly cause a crack to occur during rolling. To obviate the above defects teeming must be very carefully controlled. It must be slow enough to prevent cracking, while still being fast enough to prevent lapping, "hanging crusts," and the formation of excessive ladle skull. The difficulty of producing a splash-free ingot increases with decreasing teeming speed.

Several methods of regulating teeming speeds are possible, as up-running, tundishing, and group teeming of various types. Each method has its advantages and disadvantages; the major disadvantage over direct teeming being increased cost and losses. In any case, constant teeming speed is still dependent upon the pot characteristics. In certain plants it is possible to regulate the time of filling each mould by varying the number of moulds attached to each single runner in the case of up-running. Again, it is sometimes possible to teem a whole heat in one cluster, though this latter does not apply to large furnace plants. The former does not give successful results in plants producing large ingots.

A method of teeming sometimes used consists of teeming with the nozzle partially closed by the stopper. With semi-killed and rimming steels this is liable to give a spreading and splashy stream, also the stopper end may become eroded to such an extent that it does not properly close the nozzle when required. This method of control can be successful with up-run teeming, as the spreading stream has no effect upon the steel in the moulds. With direct teeming of the steel types mentioned, it is not generally successful.

The best and most simple method of teeming, when it can be used, is the direct method, the steel passing through a nozzle, having the desired characteristics, directly into the mould. As ingot size increases so do the advantages of

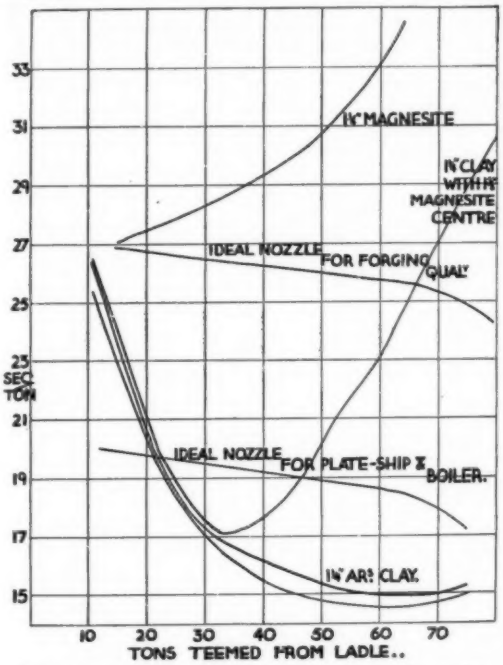
teeming by this method. No matter what method of teeming is to be used, however, the nozzle characteristics are of importance, and these depend entirely upon the refractory manufacturer.

Nozzle Characteristics.

The ideal nozzle is one which would give a gradual increase of speed of teeming as the ladle empties. The effect on the ingot of the slightly increased speed would be opposed by the slightly decreased temperature of the steel still within the ladle. This is not so simple as would at first appear, the rate at which the steel leaves the ladle being dependent, amongst other things, upon the following factors :—

(*a*) Head of steel in the ladle.
(*b*) Size and type of nozzle.
(*c*) Degree of fluidity of the steel.
(*d*) Type of steel.

Head of Steel.—The head gradually falls throughout the teeming operation. It may commence as high as 10 ft.



Figs. 3 and 4. Showing effect of various refractories on the rate of teeming of similar steels.

Nozzle Size.—At any point during teeming the nozzle size depends upon original size ; refractory material used ; the erosive nature of the steel, which will often vary from cast to cast ; temperature of the steel, hot metal cutting most rapidly ; steels with a slag cover on the ladle appear to have a greater erosive effect on the nozzle than those without.

Degree of Fluidity of the steel depends upon the temperature for a particular type ; type of steel ; and additions made to the ladle.

From remarks already made, the impossibility of producing a pot which will be ideal for every case is obvious. Figs. 3 and 4 show the wide deviation of present pots from the ideal, and this is now well known to refractory manufacturers, who are very persistently endeavouring to improve their products in this direction. The properties of the products and the degree of success which has attended their efforts is briefly reviewed below.

For teeming ordinary steels for subsequent rolling to sections (up-run or direct teeming) we use a plain 1¼-in. fire clay nozzle, made of Sheffield district clay ; this being the most useful ordinary pot we have tried. For plate steels we require slower teeming, and Fig. 4 shows that after some 25 tons of steel have been teemed from the ladle in our case, the speed of teeming is too rapid. Increased defective losses in the mill result. To overcome this difficulty we have to use nozzles with magnesite inserts, as shown in Fig. 6.

Magnesite Ring Pots.—Use is made of the well-known properties of magnesite, to resist attack and erosion by molten steel. Owing to the high-thermal conductivity of magnesite (apart from cost and difficulty of manufacture) a whole pot made of this material would be unsatisfactory. To overcome the difficulties as much as possible a small ring of magnesite is inserted in a clay pot and cemented into place. This ring controls the speed of teeming, and will seldom increase its diameter by as much as ⅛ in., even after passing 85 tons of soft steel. Under these circumstances the speed of teeming a ladle of steel would steadily decrease from beginning to end, as the head in the ladle decreases. (See 1¼ in. magnesite nozzle curve, Fig. 3) If the teeming speed of the first ingot is correct then the later ones are too long, time and steel being thereby wasted. To partially overcome this difficulty the characteristics of clay and magnesite are combined (see Figs. 7 and 8), a larger magnesite ring being used (1⅜ in. diameter) in a small clay pot (1¼ in.). The advantages in teeming from the viewpoint of time and skill loss are obvious, but with a curve of

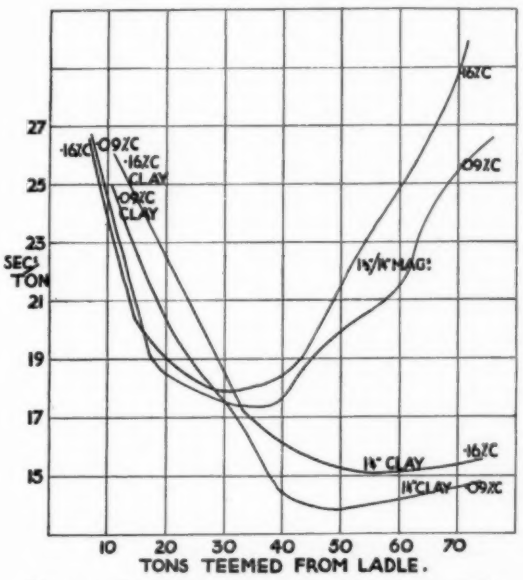


Fig. 5. Showing effect of type of steel on nozzle refractory.

this shape few ingots can be teemed at the correct speed, the rest being either too fast or too slow.

A further disadvantage occurs with regard to the shape of the stream of steel from the ladle. Up to say 20 to 25 tons out, the rate of teeming is controlled by the clay part of the nozzle, it being smaller than the magnesite, and the stream and shape is good. At some 25 to 30 tons out the clay nozzle begins to get larger than the magnesite ring. At this point the widening clay hole drags on the stream and often causes it to spread slightly, giving a little splash and spatter on the mould wall. This continues for a few tons until the clay portion is worn bigger than the magnesite, when the stream again becomes normal. This spatter is a disadvantage with all composite pots.

In spite of their many disadvantages magnesite ring pots are still invaluable for certain classes of steel. Ordinary clay pots are now, however, being improved considerably and will probably partially supersede magnesite centre pots for steels which do not require a very low teeming speed.

In spite of the usefulness of magnesite centre pots, no one having connection with steel teeming will be satisfied until something far superior is introduced. In an effort to do this the following materials have been tried :—

Chrome-clay pots, made, as the name implies, from chrome ore and fire-clay mixtures. These may offer promise if

correct mixture could be produced, but the few tried were so poor that they were not persisted with.

High-alumina pots, manufactured from mixtures of clay and alumina, suffered from two disadvantages :—

(*a*) High cost, due mainly to the burning required (when made into whole pots). They might have been more successful as rings, similar to magnesite.

(*b*) When burned to normal clay-burning temperatures they were insufficiently vitrified, in consequence they eroded more rapidly than clay alone.

"Diazite" rings have been tried. These are similar in principle to the magnesite pots, but diazite is used. It was hoped that the rate of erosion of this material would be somewhere between that of clay and magnesite. A few trial samples soon proved erosion to be faster than magnesite, and a more complete trial indicates that, on the average, diazite is little, if any, more resistant to erosive attack by molten steel *under these conditions* than clay. The approximate analysis of diazite rings is as follows :—

SiO_2.	FeO.	Al_2O_3.	MgO.	Cr_2O_3.
4·5%	16·0%	23·0%	19·0%	36·0%

An example of an improved clay pot is shown in Fig. 8

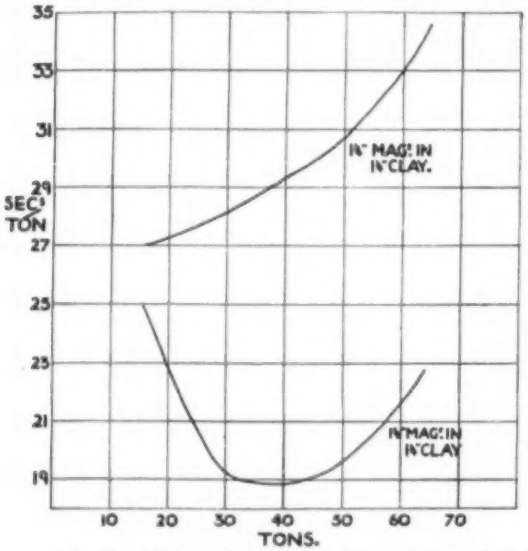


Fig. 7. Showing the difference in pouring speed with different sizes of magnesite inserts.

compared with a magnesite and a good-quality ordinary clay. This improved pot (R.H. 20) contains some 38% Al_2O_3. Its rate of erosion is reduced by means of special treatment of the clay and prolonged burning in the kilns. It probably represents the greatest step that has yet taken place towards improving the properties of a straight clay nozzle. It indicates also the possibilities of a close co-operation between refractories and steelmakers, under which conditions it has been developed

Teeming Speed.

At the works of the Appleby-Frodingham Company ingots are made for rolling from 2 to 25 tons in weight, and from 6 tons upwards all are teemed direct.

Space does not permit here a discussion on the relative merits of direct or up-run teeming. We find the following :

(*a*) Best results accrue from direct teeming, with 6 tons upwards.

(*b*) Below 6 tons there is little doubt that up-runs warrant their extra cost.

All plates and large forging blooms are made from the larger ingots ; in consequence, the question of teeming speed is very important to us.

Teeming speed is sometimes expressed in inches per minute rise of steel in the mould. This has no comparative significance unless the mould size is known. For instance, in a 6-ton slab mould a rise of 40 in. per minute will give good results, whereas for a forging ingot of 25-tons weight the rate of rise should not exceed 6 in. per minute to ensure really good ingot.

The application of the various speeds outlined may be briefly classified :—

(*a*) All ingots above 11 tons must be slowly teemed by magnesite nozzles.

(*b*) Ingots of 6 to 10 tons are best if teemed fairly slowly. The success or failure of more rapid teeming is dependent upon various factors, such as : State of oxidation of the material—*i.e.*, rimming, semi- or fully killed ; the latter requiring the slower and the former permitting of faster teeming ; tapping temperature, low temperature permitting more rapid teeming ; and the composition of steel. Dead soft and ingot-iron types may be teemed rapidly. Higher-carbon classes must be more slowly teemed. Higher-carbons have less erosive effect on the nozzles, therefore good clay pots, of small diameter, are generally satisfactory.

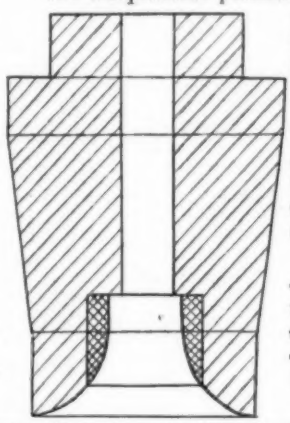


Fig. 6. Showing clay pot with magnesite inset.

(*c*) Ingots up to 4 tons give excellent results when teemed up-run in clusters of four or six moulds per feeder, using ordinary clay pots, $1\frac{1}{4}$ in. to $1\frac{3}{4}$ in. diameter.

The following will illustrate the above from tests of two classes :—

(*a*) 0·20/0·25 carbon steel in 15-ton ingots for forging blooms. Teeming speeds as shown on graph, Fig. 7.

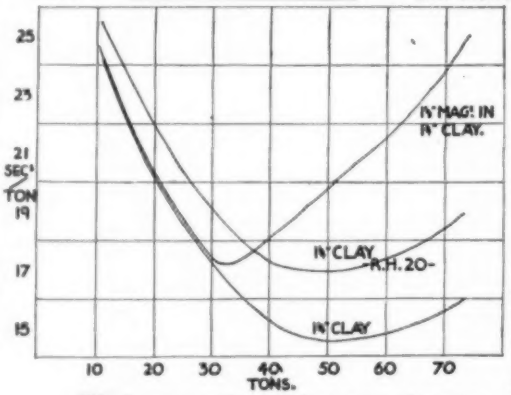


Fig. 8. Comparison of three types of nozzles.

Slower speeds gave the following loss: Cracking, 0·95% scrap ; 2·7% required slight dressing. Faster rate shown gave : Cracking, 3·07% scrap ; 13·4% required dressing. The test covered 1,100 tons of the metal.

(*b*) 0·06/0·09% carbon suppressed rimming. This class shows the effects of faster teeming, to a lesser extent, but they are still there.

Teemed more rapidly with $1\frac{1}{4}$ in. clay pot (2,370 tons comprised test) : Cracking losses (total plate + slab mills, 1·593% ; shelling losses, 0·698%.

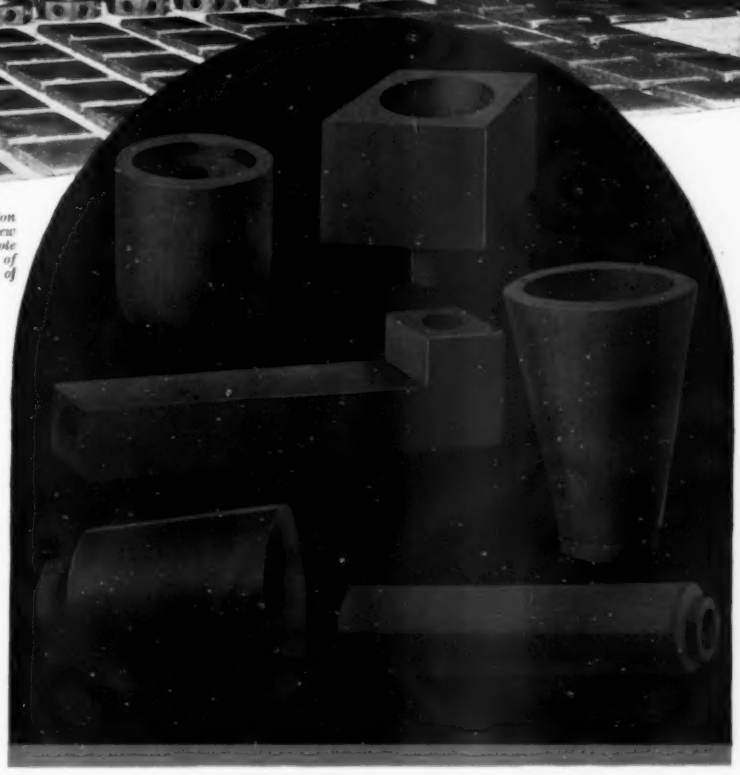
Teemed $1\frac{5}{8}$ in.—$1\frac{1}{4}$ in magnesite nozzle (1,265 tons) : Cracking losses, 0·635% ; shelling losses, 0·938%

Note the increased shelling loss with the magnesite nozzle.

Much experimental work is still proceeding on this subject, and other variables having effects upon rate of teeming by way of pot erosion require study. In conclusion, one of particular interest may be mentioned—*i.e.*, the variation of the rate of clay erosion with the FeO content of the steel. A study of this, combined with examination of the rate of iron absorption by the clay, and the effect of this absorption in *reducing* the speed of pot erosion, which it appears to do, would shed much light on the question of pot making from the refractorer's point of view.

The author desires to express his thanks to the Appleby-Frodingham Company for permission to publish these results, and the efforts of refractory makers to overcome knotty problems associated with teeming must not be overlooked.

The above illustration shows part of a new moulding floor: note the multiplicity of shapes in course of production.



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Business Notes and News

Continued Trade Improvement

Figures recently issued by the Ministry of Labour show a further fall in registered unemployment below the 2,000,000 figure at which it stood for five years until last month, when it was 1,992,941. The reduction recorded by the latest figures *viz.*, 24,977, is relatively small, but when it is remembered that normally, at this period, it is customary to record increased unemployment, owing to unemployed juveniles on leaving school, the figures become very significant and hopeful. There has been a continuance of the new high level in employment which began in January last; since then there has been a decrease in the total number of registered unemployed of over 377,000.

In the period covered by the latest returns, from July 22 to August 26, a noteworthy improvement is recorded in the iron and steel industries, general engineering, shipbuilding and ship-repairing, and these have been accompanied by a marked improvement in coalmining. The fact that these industries, which have suffered most during the years of depression, are showing such hopeful signs of recovery is an indication that the recovery is increasing confidence. There was improved employment in the motor industry, in aircraft manufacture, also in the building and the woollen and worsted industries.

It is probable that the most difficult period of the year is now passed and that further substantial progress will be recorded in the succeeding months.

Clyde Shipping Recovering

The recovery in Clyde shipbuilding and engineering is reflected in the increased revenue of the Clyde Navigation Trust, the body controlling the port of Glasgow. Mr. J. A. R. Mitchell, convener of the committee on finance, stated recently that the trust had experienced a good year, there having been continued general improvement in the trade of the port. The revenue was £869,277, against £796,935 in the previous year, an increase of £72,342. The expenditure charged to revenue was £828,837, an increase of £62,403.

During the year the total net registered tonnage of vessels entering and leaving the port was 13,699,071, an increase on that of the previous year of 681,103 tons. The total tonnage of goods imported and exported was 6,480,970, an increase of 364,518 tons. The continued improvement in the revenue, he added, had practically covered every section of the undertaking, including the graving docks.

Election of Master Cutler

Sir Samuel Roberts, M.P. for the Ecclesall division of Sheffield, was elected Master Cutler at a meeting of the Cutlers' Company at the Cutlers' Hall, Sheffield, on Saturday. Sir Samuel Roberts was Lord Mayor of Sheffield in 1919, as was his father, the first baronet, in 1899. He recently became chairman of Newton Chambers and Co., Ltd., of Sheffield, and announced that owing to his taking up of these and other important public duties he will not seek re-election at the next General Election.

Coal-Oil Plant

Some indication of the success already achieved by the Coal and Allied Industries, Ltd., the coal oil works at Seaham Harbour, from their plant is shown by the decision to lay the foundations of a duplicate plant. Work of preparation is in such a forward state that the first unit is already being heated up preparatory to being put into actual operation, the burners in the carbonisation battery having been set going. It is hoped that the works will be in full production by the end of this month.

The present plant will handle about 500 tons of coal per day and will produce about four million gallons of motor spirit, four million gallons of diesel oil, 100,000 tons of semi-coke, and hundreds of tons of valuable by-products per annum.

Liner to be Broken up at Jarrow

The *Olympic*, veteran ship of the Atlantic, which made her maiden voyage twenty-four years ago, has been purchased with a view to her being broken up at Jarrow. The purchase was made by Sir J. Jarvis with this object. It will be remembered that efforts were made to purchase the *Mauretania* for Tyneside, and there are many on Tyneside who wish the effort had been successful.

The 46,439-ton *Olympic*, with her graceful hull, crossed the Atlantic about 500 times, and even towards the end of her career she remained one of the most popular ships in the North Atlantic service. She has been bought in an effort to start a substantial shipbuilding industry in the distressed area of Jarrow and is part of an attempt by Sir John to restart the wheels of industry in this locality and to provide raw materials for the projected steelworks. Industrials on the Tyne are hopeful that the programme will include the steelworks at Jarrow, when it is confidently believed that a group of industries would be formed to consume a substantial portion of the steel manufactured.

Direct Rolling into Metal Sheets

The possibility of rolling molten steel into sheets, and eliminating such expensive intermediate operations as ingot casting, soaking-pits, blooming and breakdown mills, as in the current practice was discussed by Mr. Boris Skegnin in the July, 1933 issue of this Journal. He suggested a method whereby billets are cast direct with the object of curtailing the amount of rolling necessary and proposed a continuous casting operation. Recent reports from America indicate that successful experiments have been carried out in this direction. Particular reference is made to an experiment in the direct rolling of stainless strip from the molten metal in a single operation.

It is understood that a number of plants are in commercial operation, working the system on non-ferrous metals, with considerable success. It is believed that this revolutionary practice will be applied with an equal degree of success in the production of steel sheet when special plant has been designed for the purpose.

The Brightside Foundry and Engineering Co., Ltd., have secured an order for a large clay-preparing plant, and also contracts for a complete rolling-mill for medium steel sections, a large non-ferrous sheet mill, a mill for rolling steel sheets, and a wire-rod rolling-mill.

FILE THIS IN YOUR CABINET

You will then be able to refer to contents of previous issues easily.

METALLURGIA. *Contents.* For SEPTEMBER, 1935.

MARKET PRICES

ALUMINIUM.

98/99% Purity	£100	0	0

ANTIMONY.

English	£75	0	0
Chinese	69	0	0
Crude	28	10	0

BRASS.

Solid Drawn Tubes	lb.	9½d.
Brazed Tubes	„	11½d.
Rods Drawn	„	8d.
Wire	„	7⅞d.
*Extruded Brass Bars	„	4½d.

COPPER.

Standard Cash	£33	13	0
Electrolytic	37	5	0
Best Selected	36	0	0
Tough	35	10	0
Sheets	64	0	0
Wire Bars	37	10	0
Ingot Bars	37	10	0
Solid Drawn Tubes	lb.	10d.	
Brazed Tubes	„	10d.	

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	0	3	3
‡Ferro Tungsten	„	0	3	0
Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.				
NOMINAL: 2–4% Carbon, scale 11/- per unit	ton	29	15	0
NOMINAL: 4–6% Carbon, scale 7/- per unit	„	22	7	6
NOMINAL: 6–8% Carbon, scale 7/- per unit	„	21	12	0
NOMINAL: 8–10% Carbon, scale 7/- per unit	„	21	12	6
§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steelwork. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/0 per unit	„	33	0	0
Guar. max. 1% Carbon, scale 12/6 per unit	„	36	5	0
§Guar. max. 0·7% Carbon, scale 12/6 per unit	„	37	5	0
‡Manganese Metal 97–98% Mn.	lb.	0	1	2
‡Metallic Chromium	„	0	2	5
§ Ferro-Vanadium 25–50%	„	0	12	8
§ Spiegel, 18–20%	ton	7	10	0
Ferro Silicon—				
Basis 10%, scale 3/- per unit	ton	6	5	0
20/30% basis 25%, scale 3/6 per unit	„	8	17	6
45/50% basis 45%, scale 5/- per unit	„	12	15	0
70/80% basis 75%, scale 7/- per unit	„	17	17	6
90/95% basis 90%, scale 10/- per unit	„	28	17	6
§ Silico Manganese 65/75% Mn., basis 65% Mn.	„	13	10	0
§ Ferro-Carbon Titanium, 15/18% Ti	lb.	0	0	4½
Ferro Phosphorus, 20–25%	ton	15	15	0
§ Ferro-Molybdenum, Molyte	lb.	0	4	6
§ Calcium Molybdate	„	0	4	2

FUELS.

Foundry Coke—			
S. Wales	—	1	5	0
Scotland	—	1	8	0
Durham	0 19 0 to	1	2	0
Furnace Coke—			
Scotland	—	1	5	0
S. Wales	—	1	0	0
Durham	—	0	17	6

GUN METAL.

*Admiralty Gunmetal Ingots (88 : 10 : 2)	£54	0	0
*Commercial Ingots	40	0	0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards	lb.	0	0	9
*Cored Bars	„	0	0	11

LEAD.

Soft Foreign	£15	15	0
English	17	15	0

MANUFACTURED IRON.

Scotland—			
Crown Bars, Best	£10	5	0
N.E. Coast—			
Rivets	10	10	0
Best Bars	10	2	6
Common Bars	9	5	0
Lancashire—			
Crown Bars	9	12	6
Hoops £10 10 0 to	12	0	0
Midlands—			
Crown Bars	9	12	6
Marked Bars	12	0	0
Unmarked Bars from	7	5	0
Nut and Bolt Bars £7 10 0 to	8	0	0
Gas Strip	10	12	6
S. Yorks—			
Best Bars	10	15	0
Hoops £10 10 0 to	12	0	0

PHOSPHOR BRONZE.

*Bars, "Tank" brand, 1 in. dia. and upwards—Solid	lb.	9d.
*Cored Bars	„	11d.
†Strip	„	11d.
†Sheet to 10 W.G.	„	11½d.
†Wire	„	1/-
†Rods	„	11d.
†Tubes	„	1/1½
†Castings	„	1/-

†10% Phos. Cop. £30 above B.S.
†15% Phos. Cop. £35 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland—			
Hematite M/Nos.	£3	11	0
Foundry No. 1	3	12	6
„ No. 3	3	10	0
N.E. Coast—			
Hematite No. 1	3	8	0
Foundry No. 1	3	10	0
„ No. 3	3	7	6
„ No. 4	3	6	6
Silicon Iron	3	10	0
Forge	3	6	6
Midlands—			
N. Staffs Forge No. 4	3	7	0
„ Foundry No. 3	3	11	0
Northants—			
Foundry No. 1	3	10	6
Forge No. 4	3	2	6
Foundry No. 3	3	7	6
Derbyshire Forge	3	6	0
„ Foundry No. 1	3	14	0
„ Foundry No. 3	3	11	0
West Coast Hematite	3	7	0
East „ „	3	8	0

SWEDISH CHARCOAL IRON AND STEEL.

Pig Iron Kr. 103
Billets Kr. 240-310 £12 7 6–£16 0 0
Wire Rods Kr. 290-340 £15 0 0–£17 10 0
Rolled Bars (dead soft) Kr. 200-220 £10 6 0–£11 7 0
Rolled Charcoal Iron Bars Kr. 290 15 0 0
All per English ton. f.o.b. Gothenburg.
Converted at £1 = Kr. 19.40 approx.

SCRAP METAL.

Copper Clean	£27	0	0
„ Brazery	22	0	0
„ Wire		—	
Brass	18	0	0
Gun Metal	25	0	0
Zinc	9	0	0
Aluminium Cuttings	66	0	0
Lead	13	10	0
Heavy Steel—			
S. Wales	2	15	6
Scotland	2	10	0
Cleveland	2	12	0
Cast Iron—			
Midlands	2	7	6
S. Wales	2	11	0
Cleveland	2	12	0
Steel Turnings—			
Cleveland	1	15	0
Midlands	1	14	0
Cast Iron Borings—			
Cleveland	1	5	0
Scotland	1	17	6

SPELTER.

G.O.B. Official		—	
Hard	£12	10	0
English	16	0	6
India	13	5	0
Re-melted	15	15	0

STEEL.

Ship, Bridge, and Tank Plates Scotland	£8	15	0
North-East Coast	8	15	0
Midlands	8	17	6
Boiler Plates (Land), Scotland	8	10	0
„ „ (Marine) „		—	
„ „ (Land), N.E. Coast	8	10	0
„ „ (Marine) „	8	17	6
Angles, Scotland	8	7	6
„ North-East Coast	8	7	6
„ Midlands	8	7	6
Joists	8	15	0
Heavy Rails	8	10	0
Fishplates	12	10	0
Light Rails £8 10 0 to	8	15	0
Sheffield—			
Siemens Acid Billets	9	2	6
Hard Basic £6 17 6 to	7	2	6
Medium Basic £6 12 6 and	7	0	0
Soft Basic	5	10	0
Hoops £9 10 0 to	9	15	0
Manchester Hoops £9 0 0 to	10	0	0
Scotland, Sheets 24 B.G.	10	10	0

HIGH SPEED TOOL STEEL.

Finished Bars 14% Tungsten	lb.	2/-
Finished Bars 18% Tungsten	„	2/9
Extras		
Round and Squares, ½ in. to ¼ in.	„	3d.
Under ¼ in. to ⅛ in.	„	1/-
Round and Squares 3 in.	„	4d.
Flats under 1 in. × ⅛ in.	„	3d.
„ „ ½ in. × ¼ in.	„	1/-

TIN.

Standard Cash	£219	0	0
English	219	5	0
Australian	219	10	0
Eastern	217	0	0

Tin Plates I.C. 20 × 14 box 18/2

ZINC.

English Sheets	£23	10	0
Rods	29	0	0
Battery Plates		—	
Boiler Plates		—	

*McKechnie Brothers, Ltd. Sept. 14 † C. Clifford & Son, Ltd., Sept. 14 ‡ Murex Limited, Sept. 14

Subject to Market fluctuations. Buyers are advised to send inquiries for current prices.

§ Prices ex warehouse, Sept. 14